

A THEORETICALLY INFORMED MHEALTH INTERVENTION TO  
IMPROVE MEDICATION ADHERENCE BY  
ADULTS WITH CHRONIC CONDITIONS:  
TECHNOLOGY ACCEPTANCE MODEL-BASED  
SMARTPHONE MEDICATION REMINDER APP TRAINING SESSION

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Medication nonadherence among middle-aged to older adults with chronic conditions often stems from forgetting to take or fill medications as prescribed. A pilot study indicated the feasibility of technology acceptance model (TAM)-based smartphone medication reminder app (SMRA) training as a way to promote their app use and medication adherence. This dissertation assesses the viability and effect size of the modified TAM-based SMRA training in promoting app use and medication adherence, as well as its delivery design in preparation for a larger efficacy study. A two-group pretest-posttest design was employed. Twenty-nine adults aged over 40 years and taking medications for chronic condition management were recruited from Midwestern university and community sites. The training group ( $n = 15$ ) received the modified TAM-based SMRA training; whereas the non-training group ( $n = 14$ ) self-navigated app features. The training group reported significantly higher levels of perceived usefulness, perceived ease of use, positive subjective norm, and intention to use the app. In addition, the training group reported a higher proportion of active app use than the non-training group. Modified TAM-based SMRA training was not viable in increasing the levels of

medication adherence variables. Effect sizes suggested at least 52 participants as a sample size for a larger efficacy study. Participants suggested that training could be improved by scheduling separate group training for iPhone and Android phone users, providing a live online training option, providing small group training with peer helper, tailoring training length to participant preference, and working with family members and healthcare providers as co-trainees and co-trainers.

Elizabeth M. Goering, Ph.D., Chair

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## LIST OF ABBREVIATIONS

eHealth	Electronic health
ICT	Information and communication technology
IRB	Institutional review board
MASES-R	Revised medication adherence self-efficacy scale
mHealth	Mobile health
MMAS	Morisky medication adherence scale
MPR	Medication possession ratio
PPT	Microsoft PowerPoint
SMRA	Smartphone medication reminder app
SMS	Short message service
TAM	Technology acceptance model

## CHAPTER ONE

### INTRODUCTION

#### **Prevalence of Chronic Conditions in the United States**

Chronic conditions are a leading cause of mortality and a critical public health issue, accounting for healthcare costs of as much as \$3.3 trillion per year in the United States (National Center for Chronic Disease Prevention and Health Promotion [NCCDPHP], 2019). Approximately 117 million U.S. adults report having chronic conditions including arthritis, asthma, cancer, chronic obstructive pulmonary disease (COPD), coronary heart disease, diabetes, hepatitis, hypertension, kidney disease, or stroke (Ward, Schiller, & Goodman, 2014), and four in ten adults have two or more chronic conditions (NCCDPHP, 2019).

#### **Significance of Medication Adherence in Chronic Condition Management**

Medication adherence, defined as the degree to which people take medications in a way that corresponds with a healthcare provider's prescription (Bartlett Ellis, Knisely, Boyer, & Pike, 2017; Osterberg & Blaschke, 2005; World Health Organization, 2003), is critical to managing chronic conditions. Medication nonadherence significantly impedes treatment progress (e.g., increasing hospitalization) and increases mortality (Fitzgerald et al., 2011; Glass et al., 2015; Ho et al., 2006). For example, in one study, medication nonadherence was a significant predictor of increased risk of hospitalization and mortality among patients with heart failure (Fitzgerald et al., 2011). In another study, Glass et al. (2015) found that the more doses of antiretroviral therapy patients with human immunodeficiency virus (HIV) missed, the more likely those patients were to be at increased risk of viral failure and mortality. Ho et al. (2006) reported that when

compared to adherent diabetic patients, nonadherent patients were at increased risk of hospitalization and mortality. In addition, blood pressure, low-density lipoprotein cholesterol, and glycosylated hemoglobin levels were higher for nonadherent patients than for adherent patients.

In terms of impeding treatment progress, medication nonadherence burdens patients and their caregivers with significant medical costs (Cutler, Fernandez-Llimos, Frommer, Benrimoj, & Garcia-Cardenas, 2018). Medication nonadherence was reported as a significant factor contributing to preventable medical costs totaling up to \$290 billion per year in the United States (New England Healthcare Institute, 2009).

### **Factors Associated with Medication Nonadherence**

Medication nonadherence is attributable to a variety of factors (Yap, Thirumoorthy, & Kwan, 2016). Specifically, lower level of medication adherence has been found to be prevalent in those who are female and nonwhite (Billimek et al., 2015; Patel et al., 2016; Poon, Lal, Ford, & Braun, 2009; Rolnick, Pawloski, Hedblom, Asche, & Bruzek, 2013), those with low education and income levels (Kirkman et al., 2015; Manteuffel et al., 2014; Marcum et al., 2013; Rolnick et al., 2013), those without caregivers (Trivedi, Bryson, Udris, & Au, 2012), those with low level of patient-provider interaction such as adherence-related dialogue (Oetzel et al., 2015; Schneider, Kaplan, Greenfield, & Wilson, 2004), those who smoke and drink (Agh, Inotai, & Meszaros, 2011; Hawkins et al., 2012), those who report low level of health literacy (Mayo-Gamble & Mouton, 2018), those who have concerns about medications (Dillon et al., 2018), and those who do not think medication adherence is helpful and important to manage chronic conditions (Wilhelm, Rief, & Doering, 2018).

In addition to these factors, medication nonadherence is also attributable to medication factors such as difficulty taking medications as prescribed due to complex medication schedules (Yap et al., 2016). For example, it is often required that patients take more than eight prescribed medications at different times of day to manage their chronic conditions such as hypertension and diabetes (Libby et al., 2013), and those with a higher number of prescribed medications are likely to report a lower level of medication adherence (Rolnick et al., 2013).

### **Middle-Aged to Older Adults with Chronic Conditions: Group at Risk for Nonadherence**

Middle-aged to older adults comprise three-quarters of U.S. adults with chronic conditions and appear to be a group at risk for medication nonadherence. They often report medication nonadherence for reasons such as forgetting to take or fill medications as prescribed (Langer Research Associates, 2013; Patton et al., 2018).

Forgetfulness in this group might be attributable to polypharmacy and age-related cognitive impairment factors. Regarding the polypharmacy factor, when compared to 2% of U.S. adults aged 18 to 44 years, 14% of those aged 45 to 64 years and 33% of those aged 65 years or older report managing three or more conditions (Ward et al., 2014). This indicates that the older the people are, the more likely they are to manage multiple conditions with polypharmacy. As mentioned previously, polypharmacy is likely to hinder people from both taking and refilling medications in a timely manner. In addition, the older the people are, the more likely they are to report difficulty remembering to take all medications as prescribed due to age-related cognitive impairment (Hawkins et al., 2012).

In addressing this issue, existing studies have indicated that medication reminder technologies (Mira et al., 2014; Pernell et al., 2017) could be particularly useful to middle-aged to older adults with chronic conditions, helping them to better remember to take and refill medications in the presence of polypharmacy and age-related cognitive impairment factors. However, the availability of medication reminder technologies per se cannot ensure that individuals in this group will automatically and easily use the technologies to support medication adherence on their own.

It has been found that the older the people are, the less likely they are to use electronic health (eHealth) technologies (Reiners, Sturm, Bouw, & Wouters, 2019), such as the Internet (e.g., for disease and treatment information and emotional support; Rising, Bol, & Kreps, 2015), social media (Tennant et al., 2015), and health-related smartphone apps (Cho, Park, & Lee, 2014). Middle-aged to older adults report more difficulty adapting to new technology than younger adults (van Volkom, Stapley, & Amaturro, 2014). Their limited eHealth technology use is attributable to aged-related limited eHealth literacy (Xesfingi & Vozikis, 2016) or an ability to understand and utilize such technologies for better healthcare (Norman & Skinner, 2006). In addition, although older adults are open to using new technology (Czaja & Lee, 2007), they also have fear and anxiety about the learning process (Gatti, Brivio, & Galimberti, 2017) that might discourage their technology use (Deng, Mo, & Liu, 2014). Considering these findings, the self-adoption and use of medication reminder technologies could be challenging for middle-aged to older adults with chronic conditions in the presence of age-related limited eHealth literacy and fear and anxiety about initiating technology use.

This dissertation seeks to enhance our understanding of the communication intervention needed to address these challenges and promote the use of medication reminder technologies among middle-aged to older adults with chronic conditions. In the next section, an overview of the dissertation is provided.

### **Dissertation Overview**

The purpose of this dissertation is to assess the utility of smartphone medication reminder app (SMRA) training as a communication intervention to promote SMRA use and medication adherence among middle-aged to older adults with chronic conditions. SMRA training for this dissertation is guided by the technology acceptance model (TAM; Davis, 1989; Davis, Bagozzi, & Warshaw, 1989) and was modified based on findings from the pilot study (Park, Goering, Head, & Bartlett Ellis, 2017). In addition, this dissertation considers avenues to further improve the content and delivery of the modified TAM-based SMRA training before embarking on a larger efficacy study.

Following this introductory chapter, Chapter Two presents a review of relevant literature. In this chapter, I discuss the utility of existing medication reminder technologies and consider cost-related barriers to using many of these technologies as an intervention tool for promoting medication adherence. I then explore the utility of SMRA as a cost-effective medication reminder technology to promote medication adherence for middle-aged to older adults with chronic conditions. After establishing the viability of SMRA as a technology with potential to improve medication adherence, I provide an overview of TAM studies on a variety of eHealth technologies to help understand relevant user perceptions and consider interventions for promoting technology use. I then discuss existing studies related to training as an intervention method to promote



technology use, particularly among middle-aged to older adults. Finally, I discuss the pilot study for this dissertation that was conducted to fill the gap between existing TAM literature and technology training literature. This pilot study involved the design of TAM-based SMRA training as a promising app promotion intervention. I conclude the literature review with the introduction of the three aims of the dissertation (the assessment of viability of modified TAM-based SMRA training in promoting app use and medication adherence, the estimation of effect sizes, and the assessment of delivery method required for a larger efficacy study) and the twelve research questions the dissertation seeks to answer.

Chapter Three is the methods section. In this chapter, I describe the dissertation as a multi-method study with a two-group pretest-posttest design. I then detail research materials, including Microsoft PowerPoint (PPT) slides for the training group and non-training group, survey questionnaires, and the telephone interview guide. I also discuss inclusion and exclusion criteria for the research and describe participant recruitment strategies. I then describe the data collection procedures and quantitative and qualitative data analysis plans.

Chapter Four is the results section. I begin this chapter reporting participant characteristic data and then present findings for each of three aims for this dissertation. In sum, regarding the first aim, the results indicated that the modified TAM-based SMRA training was viable in promoting app use through targeting perceived usefulness and perceived ease of use. Regarding the second aim, the results suggested at least 52 participants (26 per group) as a sufficient sample size for a larger efficacy study. Regarding the third aim, I present participants' opinions and feedback on the SMRA

training delivery, including training format, length, and training materials. These findings provide insight into how to better deliver the modified TAM-based SMRA training to participants for a larger efficacy study.

Chapter Five is the discussion chapter. In this chapter, I first summarize the procedure of the study and its purpose and then discuss key conclusions. I finally consider the implications, limitations, future directions, and strengths of this dissertation.

## CHAPTER TWO

### LITERATURE REVIEW

Middle-aged to older adults with chronic conditions are at risk for medication nonadherence and its negative health-related outcomes. The use of medication reminder technologies shows promise as a way to support their medication adherence. However, medication reminder technologies can only support their medication adherence if individuals find such technologies useful and usable and are willing to use technologies. This chapter provides an overview of literature related to the use of medication reminder technologies, TAM as a technology promotion intervention framework, and technology training as a technology promotion intervention method.

#### **Medication Reminder Technology**

Technologies that help address polypharmacy and age-related cognitive impairment factors appear to be a critical tool for interventions to promote medication adherence among middle-aged to older adults with chronic conditions (Anglada-Martinez et al., 2015; Kröger et al., 2017; Marcum, Hanlon, & Murray, 2017). Medication reminder technologies that have succeeded in supporting medical adherence include video- and telephone-based reminder (Fulmer et al., 1999), short message service (SMS; Anglada-Martinez et al., 2015; Finitsis, Pellowski, & Johnson, 2014; Pernell et al., 2017; Pop-Eleches et al., 2011), audiovisual reminders via a handheld device (Chan et al., 2015; Heinrich & Kuiper, 2012), an electronic medication container (Simoni et al., 2013), and the combination of an electronic medication container and SMS (e.g., messages as a second reminder; McGillicuddy et al., 2013; Vervloet et al., 2012).

Limitations of these tools, however, include important cost-related barriers to interventions using these technologies to support medication adherence in a consistent manner or at a population level. For example, an SMS might require considerable cost and efforts (e.g., manpower) for long-term interventions (Fenerty, West, Davis, Kaplan, & Feldman, 2012). In addition, the cost for handheld devices or electronic medication containers use might impede technology promotion (Heinrich & Kuiper, 2012; McGillicuddy et al., 2013).

### **Smartphone Medication Reminder App**

The use of an SMRA shows promise as a medication reminder technology that addresses the abovementioned cost-related barriers. An SMRA is a smartphone app that helps users visually keep track of their prescribed medication information (e.g., dosing schedule) and that sends reminders to users when it is time to take medications (Mira et al., 2014). Existing literature has indicated that an SMRA could be a cost-effective medication reminder technology that interventions could use to support middle-aged to older adults with chronic conditions in medication adherence.

In terms of cost and reach, SMRAs require little to no cost to use (Dayer, Heldenbrand, Anderson, Gubbins, & Martin, 2013). In addition, a Pew Research Center report indicates that smartphone ownership among U.S. adults has increased from 35% in 2011 to 81% in 2019, and now 79% of adults aged 50 to 64 years and 53% of those older than 65 years report smartphone ownership (Pew Research Center, 2019). In other words, an SMRA is a medication reminder technology available to the majority of middle-aged adults and more than half of older adults.

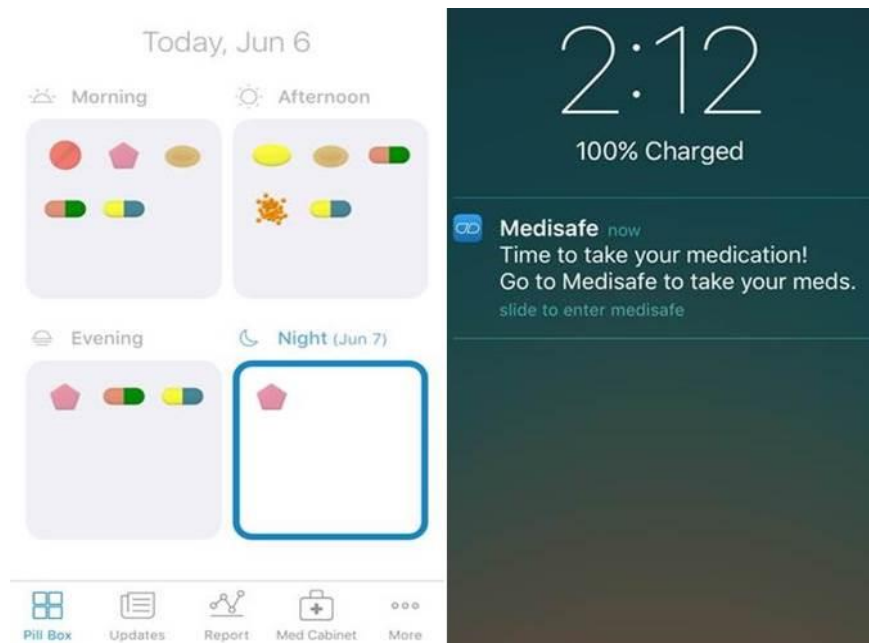
In addition, SMRAs have already been found effective in supporting medication adherence (Mira et al., 2014; Santo et al., 2019). These findings have been consistent, irrespective of whether medication adherent behaviors were assessed using objective (pharmacy claim) data or subjective (self-report) data.

In one study (Santo et al., 2019), researchers conducted a randomized clinical trial of patients with coronary heart disease to assess the utility of SMRAs in supporting medication adherence. Researchers randomized participants into either of two SMRA groups with mean age of 58 years. These were the basic SMRA group with one-time daily medication taking reminder available to use and the advanced SMRA group with multiple daily medication taking reminders and other features such as medication refill reminder feature available to use. There was also a usual care group (mean age of 57 years) that received healthcare provider advice on lifestyle and cardiac rehabilitation. Medication adherence was measured using the 8-item Morisky medication adherence scale (MMAS-8; Morisky, Ang, Krousel-Wood, & Ward, 2008). After three months, it was found that both the basic SMRA group and the advanced SMRA group reported higher level of medication adherence when compared to usual care group.

In another study (Mira et al., 2014), researchers conducted a randomized controlled trial of patients managing chronic conditions with an average of more than seven prescribed medications to assess the utility of SMRA in supporting medication adherence. Researchers randomized participants into an intervention group (mean age of 71 years) that used the app for three months and a control group (mean age of 73 years) that received oral and written information about medication safety and medication taking error issues. Medication adherence was measured using the 4-item MMAS (MMAS-4;

Morisky, Green, & Levine, 1986). In addition, self-reported missed dose numbers and medication error data were collected. When compared to a baseline, the degree to which participants improved their level of medication adherence over three months was higher in the intervention group than in the control group. In addition, the proportion of participants without a missed dose was higher in the intervention group than in the control group, and the number of participants who reported making two or more medication errors decreased only in the intervention group. Furthermore, within the intervention group, both participants with information and communication technology (ICT) experience and those without ICT experience reported significantly higher level of medication adherence when compared to a baseline level.

One popular SMRA, the Medisafe<sup>®</sup> app (see Figure 1; Park et al., 2017), has been found to help patients engage in medication adherent behaviors. In one study (Wade, Clancey, & Michaeli, 2016), researchers examined the relationship between Medisafe<sup>®</sup> app use and medication persistence or “the extent to which the patient follows the regimen for the agreed-upon duration” (Haskard-Zolnierek & Williams, 2014, p. 454), among those taking antihypertensive medications (mean age of 53 years) and those taking cholesterol-lowering medications (mean age of 55 years). Using 6-month prescription refill data, researchers compared medication persistence level between Medisafe<sup>®</sup> app user group and non-user group. Results revealed that Medisafe<sup>®</sup> app user group reported a higher level of medication persistence level than the non-user group, irrespective of medication type.



*Figure 1.* Screenshots of the Medisafe® app

In one study (Morawski et al., 2018), researchers conducted a randomized clinical trial of patients with hypertension to assess the utility of Medisafe® app use in supporting medication adherence. Using the MMAS-8 (Morisky et al., 2008), the researchers measured and compared the level of medication adherence between intervention group that used the Medisafe® app for 12 weeks (mean age of 52 years) and a control group (mean age of 52 years). When compared to baseline, the degree to which participants improved their level of medication adherence over 12 weeks was higher in the intervention group than in the control group.

These reports confirm the utility of SMRAs in supporting medication adherence, but the existence of such technology may not be enough to lead middle-aged to older adults with chronic conditions to use the technology. The next logical question, then, is how to promote SMRA use. In the following section, I review relevant literature that has indicated the utility of TAM as an SMRA promotion intervention framework and

technology training as the app promotion intervention method. I then introduce the pilot study that involved the design and feasibility assessment of a TAM-based SMRA training for promoting app use.

### **Technology Acceptance Model as an SMRA Promotion Intervention Framework**

Several studies have assessed the utility of using theory in helping interventions meet health promotion goals. In one, researchers conducted a meta-analysis of the studies on interventions to promote health behaviors and health-related outcomes using text messages. The results indicated that the effect size on outcome variables was larger for theory-based interventions when compared to non-theory-based interventions (Head, Noar, Iannarino, & Harrington, 2013). In addition, research has supported the utility of interventions that target theoretical determinants of health behaviors, such as medication adherence (Hamine, Gerth-Guyette, Faulx, Gree, & Ginsburg, 2015; Patton, Hughes, Cadogan, & Ryan, 2017). In addressing how to lead people to use an SMRA, TAM—a theory adapted from the theory of reasoned action (Fishbein & Ajzen, 1975) and focusing on the determinants of information technology use (Davis et al., 1989)—serves as a useful app promotion intervention framework (Park et al., 2017).

TAM considers perceived usefulness, perceived ease of use, and positive subjective norm as the determinants of intention to use a technology and considers intention to use a technology as the determinant of actual technology use (Venkatesh & Davis, 2000). Perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis, 1989, p. 320). A positive link between perceived usefulness and intention to use a technology has been reported. For example, studies have found that perceived usefulness was positively



related to intention to use technologies, such as open source software (Gallego, Bueno, Racero, & Noyes, 2015) and smartphone (Joo & Sang, 2013).

Perceived ease of use is defined as “the degree to which a person believes that using a particular system would be free of effort” (Davis, 1989, p. 320). A positive link between perceived ease of use and intention to use a technology has been well-established. For example, it has been reported that perceived ease of use was positively related to intention to use technologies, such as workplace information technology (Mariani, Curcuruto, & Gaetani, 2013) and e-learning platform (Escobar-Rodriguez & Monge-Lozano, 2012).

Subjective norm is defined as a “person’s perception that most people who are important to him [her] think he [she] should or should not perform the behavior in question” (Fishbein & Ajzen, 1975, p. 302). A positive link between positive subjective norm and intention to use a technology has been reported. For example, studies have found that positive subjective norm was positively related to intention to use technologies such as mobile cloud storage service (Arpaci, 2016) and social networking sites (Choi & Chung, 2013).

Intention within TAM is defined as a “person’s subjective probability that he [or she] will perform the behavior in question” (Fishbein & Ajzen, 1975, p. 12). A positive link between intention to use a technology and actual technology use has been reported. For example, studies have found that intention to use a technology was positively related to actual use of technologies such as Internet banking (Martins, Oliveira, & Popovič, 2014) and mobile learning system (Chen, Sivo, Seilhamer, Sugar, & Mao, 2013).

TAM has been utilized to understand the determinants of a variety of eHealth and mobile health (mHealth) technologies (Rahimi, Nadri, Afshar, & Timpka, 2018). These include wearable technology for health monitoring (Li, Ma, Chan, & Man, 2019), health-related smartphone apps (Wang, Park, Chung, & Choi, 2014), mobile care service (Lin & Yang, 2009), patient/health portal (Kim & Park, 2012; Lazard et al., 2016; Portz et al., 2019), and patient-provider communication service (e.g., email; Klein, 2007; Wilson & Lankton, 2004). In one study, researchers applied TAM to understand the determinants of wearable technology for health monitoring among older adults, and it was found that perceived usefulness was positively related to intention to use the technology. In addition, perceived ease of use and social influence (corresponding with the concept of subjective norm) were positively related to perceived usefulness (Li et al., 2019). In another study (Lin & Yang, 2009), researchers applied TAM to understanding the determinants of mobile care service use among patients with asthma, and it was found that positive subjective norm was positively related to intention to use the service. In addition, positive subjective norm and perceived ease of use were positively related to perceived usefulness, and perceived usefulness was positively related to positive attitude toward service use. Furthermore, positive attitude toward service use was positively related to intention to use the service.

In yet another study (Lazard et al., 2016), researchers applied TAM to understanding the determinants of patient portal use among current users, and it was found that perceived ease of use was positively related to perceived usefulness, and perceived usefulness was positively related to intention to continue portal use. Klein (2007) applied TAM to understanding the determinants of patient-provider

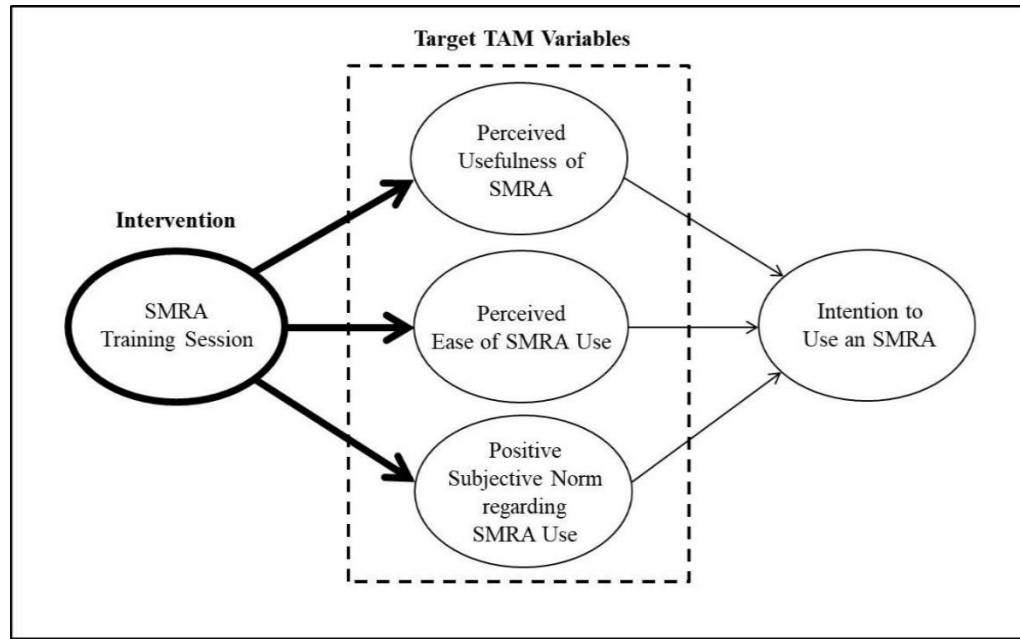
communication service use among first-time users, and it was found that perceived usefulness was positively related to intention to use the service, and intention to use the service was positively related to actual service use.

In the context of mHealth technology (e.g., smartphone healthcare app) use, the context that is most directly relevant to this study, Beldad and Hegner (2018) applied TAM to understanding the determinants of fitness app use among adult users, and it was found that perceived usefulness, perceived ease of use, and positive subjective norm were positively related to the intention to continue using the app. In another study, the researchers applied TAM to understand the determinants of smartphone fitness and weight management app among college students, and it was found that perceived usefulness and positive subjective norm were positively related to intention to use the apps (Cho, Quinlan, Park, & Noh, 2014). In yet other study, Wang et al. (2014) applied TAM to understanding the determinants of smartphone healthcare app use among adult smartphone users, and it was found that perceived ease of use was positively related to intention to use the apps and that perceived usefulness was positively related to actual app use. In the context of chronic condition management, researchers in one study applied TAM to understanding the determinants of smartphone heart failure self-management technology (e.g., heart rate tracker wrist band, heart rate monitoring app) use among older adults with a history of heart failure. They found that perceived usefulness, perceived ease of use, and social influence were all positively related to intention to use the technology (Cajita, Hodgson, Budhathoki, & Han, 2017).

Within the context of this dissertation, perceived usefulness is defined as the degree to which patients believe that using an SMRA would support them in medication

adherence (Park et al., 2017). In addition, perceived ease of use is defined as the degree to which patients believe they can use an SMRA without technical difficulty (Park et al., 2017). When considering the concept of subjective norm, family member support and healthcare provider endorsement are important to patients' chronic condition management technology use (Ware et al., 2019). Thus, in this dissertation, subjective norm is defined as the degree to which patients believe that their family members or healthcare providers think patients' SMRA use is important for medication adherence (Park et al., 2017). Finally, intention to use an SMRA is defined as the degree to which patients are willing to use the app (Park et al., 2017).

Findings from previous studies indicate that the more patients think that SMRA features are helpful in addressing their struggles in medication adherence (perceived usefulness), that app features are easy to use (perceived ease of use), and that family members or healthcare providers would find value in their (patients') app use for better medication adherence (positive subjective norm), the more likely they are to intend to use the app as a way to support medication adherence (Park et al., 2017). In this regard, for the pilot study for this dissertation (Park et al., 2017), TAM was used to design an SMRA training content that encourages participants' app use through targeting perceived usefulness, perceived ease of use, and positive subjective norm (see Figure 2; Park et al., 2017).



*Figure 2.* TAM framework describing patients’ progress from receiving an SMRA training to increasing intention to use the app

### **Technology Training as an SMRA Promotion Intervention Method**

As discussed in the previous section, TAM provides guidance on what to target to promote SMRA use, highlighting factors such as perceived usefulness, perceived ease of use, and positive subjective norm. The next important question is how to target these user perceptions that lead to SMRA use. SMRA training could be a useful way to do so, as existing studies have shown the utility of technology training as an intervention to increase confidence in and promote technology use (Vaportzis, Gow, & Clausen, 2018).

In one study of eHealth technology use (Xie, 2011), the researcher provided middle-aged to older adults with eight hours of small-group training on the use of basic Internet and online health information on National Institutes of Health website. The training involved both introductory material and hands-on experience and was conducted during two hour sessions twice per week for two weeks. Participants were divided into individual practice groups and collaborative learning groups, and both groups reported

higher levels of computer/web knowledge, computer/web skill, and eHealth literacy at post-intervention than at pre-intervention.

In another study (Ling, Ter Meer, Yumak, & Veltkamp, 2017), researchers provided older adults with training on a virtual rehabilitation exercise game. Participants practiced games (e.g., cycling, apple picking, football playing) following physiotherapists' instructions. Participants not only described games they practiced as useful and user-friendly but expressed intentions to keep playing games as part of rehabilitation.

SMRA training has also been found to be a viable intervention strategy to help and promote app use. In one study (Martin & Upvall, 2016), researchers helped those with HIV use an SMRA providing educational materials and technical support in app installation. Researchers found that participants (mean age of 53 years) thought SMRA as easy to use and useful to support medication adherence. In another study (Grindrod, Li, & Gates, 2014), researchers asked participants (mean age of 67 years) to complete SMRA-related tasks for 90 minutes with limited assistance (for those who failed in the tasks multiple times), such as recording medication information in the app, setting up reminder schedules, recording medication taking in the app, and reviewing medication information on the app. The SMRA practice sessions were useful, as participants found themselves capable of using the app over time and with training opportunity.

In Santo et al.'s (2019) study, researchers helped intervention group participants without SMRA use experience to use the app providing instructions on how to download the app, how to record medication information in the app, and how to schedule medication taking reminder. The intervention groups (both basic and advanced SMRA

groups) reported greater adherence with using the app than control group (usual care group).

In Mira et al.'s (2014) study, intervention group participants were instructed regarding the features of an SMRA in two-hour individual sessions. As discussed earlier, groups with and without ICT use experience demonstrated improved the level of medication adherence over time. Such findings indicate the utility of SMRA training in helping people benefit from app use in medication adherence, irrespective of ICT use experience.

In Morawski et al.'s (2018) study, researchers helped intervention group participants use the Medisafe® app by providing instructions on app installation and app feature use. As discussed above, the intervention group reported better adherence level using the Medisafe® app than the control group. However, existing studies have not examined the ways in which determinants of technology use within TAM (e.g., perceived usefulness and perceived ease of use) might mediate the relationship between SMRA training opportunity and app use.

In contrast, Dou et al. (2017) studied a hypertension management program that provided hypertensive patients with one-hour smartphone hypertension management app training (Dou et al., 2017). One month after the app training, the researchers conducted a survey of participants (87% of them were 40 years or older), and the results revealed that the relationship with the healthcare provider was positively related to the perceived usefulness of the app and to perceived ease of app use. Perceived ease of app use was positively related to the perceived usefulness of app. Perceived usefulness of app was positively related to intention to use the app, and intention to use the app was positively

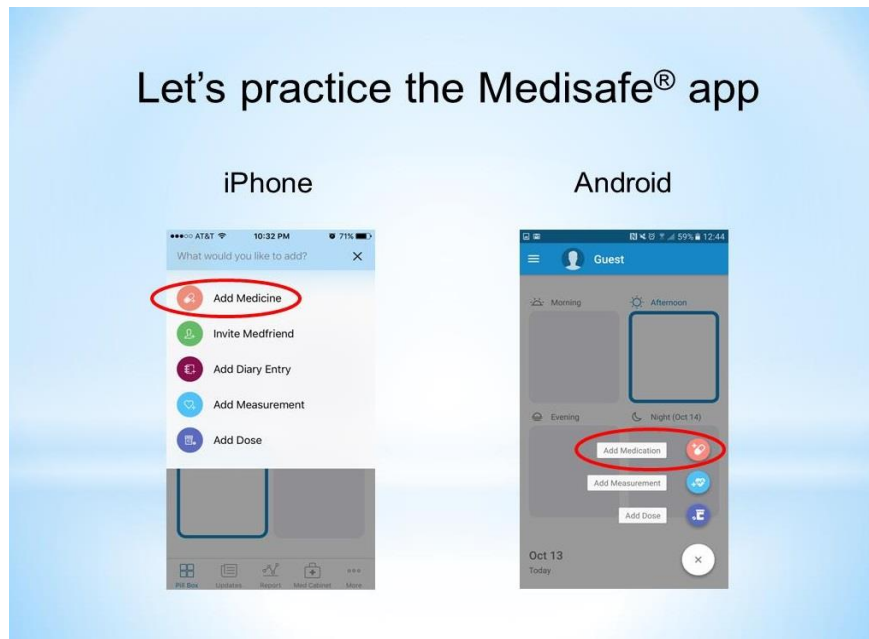
related to actual app use defined as “the ratio of a patient’s actual use of the app to that prescribed in their management plan for a certain period of time” (Dou et al., 2017, Actual Use section, para. 1). The researchers’ interpretation of these findings is that health professional-led app training might help build rapport between patients and health professionals and, thereby, help participants find app use to be useful and increase their willingness to keep using the app. However, little attention was paid to how to design the content of SMRA training that directly targets the determinants of app use within TAM and, thereby, ensure that participants will adopt app use.

### **Pilot Study: Technology Acceptance Model-Based SMRA Training**

The pilot study for this dissertation was designed to fill the gap between studies indicating TAM as an app promotion framework and SMRA training as an app promotion intervention (Grindrod et al., 2014; Mira et al., 2014; Martin & Upvall, 2016), using TAM to inform the design of SMRA training (Park et al., 2017). The pilot study and this dissertation are designed to fill the abovementioned gap identified in recent studies (Dou et al., 2017; Morawski et al., 2018; Santo et al., 2019).

For the pilot study, we developed a TAM-based SMRA training content (see Figure 3; Park et al., 2017) focusing on what middle-aged to older adults have described about SMRA use in relation to TAM variables (Grindrod et al., 2014; Martin & Upvall, 2016; Mira et al., 2014). We selected the Medisafe® app, a free SMRA developed by Medisafe Inc., for TAM-based SMRA training because of its evidence-based utility in supporting medication adherence (Wade et al., 2016).





*Figure 3.* Screenshot of TAM-based SMRA training PowerPoint slide

To target perceived usefulness, we developed content that introduced the technical utility of certain features of the app such as the virtual pillbox and reminder features, focusing on previous users' positive perceptions of SMRA as aids for medication adherence and tools for developing a medication routine (Martin & Upvall, 2016; Mira et al., 2014). Medisafe® app users can visually keep track of what medications they are on and receive text messages when it is time to take medications using the virtual pillbox and reminder features, respectively.

To target perceived ease of use, we developed step-by-step instructions on how to use app features, focusing on previous users' struggles and confusion (Grindrod et al., 2014). To target positive subjective norm, we developed content that introduced the technical utility of the Medfriend feature, focusing on previous users' attribution of SMRA use and their perceptions of others caring about their (users') medication adherence (Martin & Upvall, 2016). If Medisafe® app users overlook or do not respond to

a medication-taking reminder, Medfriends (family members, friends, or healthcare providers who use the app together) are notified of it by the app and can additionally remind users of medication taking. In sum, we designed the training content to target perceived usefulness, perceived ease of use, and positive subjective norm, and, thereby, increase the level of intention to use an SMRA.

Regarding the implementation of TAM-based SMRA training, we followed training principles that existing studies have indicated could be helpful to middle-aged to older adults in learning about the app. Such principles include inviting a small group of middle-aged to older adults to a location supportive of technology training and training them to use a technology through hands-on experience following instructions on a large screen for up to two hours for SMRA training (Cook & Winkler, 2016; Gatti et al., 2017; Grindrod et al., 2014; Mira et al., 2014; Xie, 2011). Applying such principles to the TAM-based SMRA training, we invited a small group of middle-aged to older adults who manage chronic conditions to participate in a 20-minute session in which they were trained to use the app through hands-on experience following instructions on PPT slides displayed on the large screen.

To assess the feasibility of TAM-based SMRA training in targeting TAM variables, we employed a two-group posttest-only design with an intervention group receiving a TAM-based SMRA training (i.e., training group;  $n = 5$ ) and a control group self-navigating app features (i.e., non-training group;  $n = 6$ ). Following the TAM-based SMRA training (for training group) and the self-app navigation (for non-training group), we asked participants to complete a survey and conducted focus groups to assess whether

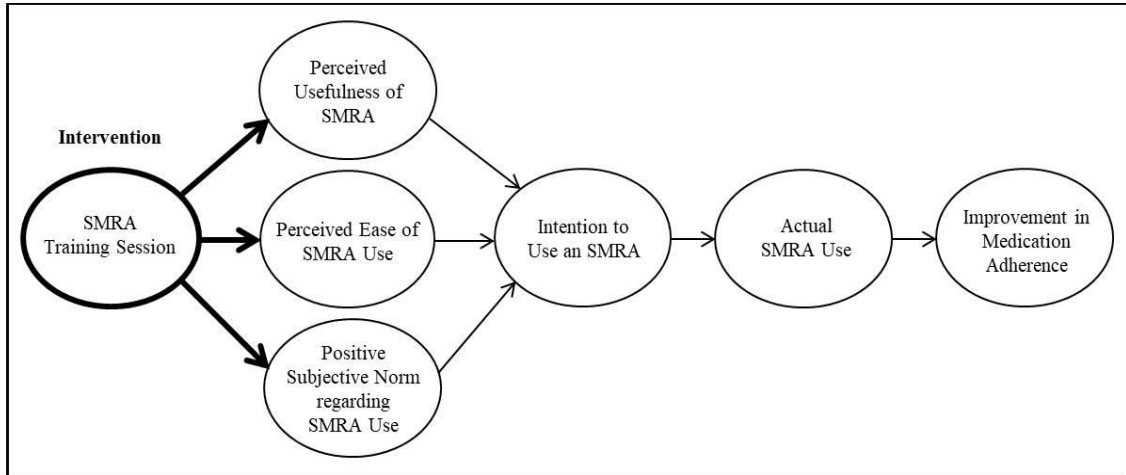
and why TAM-based SMRA training was helpful or not helpful in increasing the levels of TAM variables, respectively.

Results revealed that the training group reported higher levels of perceived ease of use and intention to use the app than the non-training group. However, training group participants' levels of perceived usefulness and positive subjective norm did not surpass non-training group participants' levels of these variables.

Throughout the focus groups, participants indicated perceived usefulness, perceived ease of use, and positive subjective norm as perceptions associated with intention to use the app. Such findings indicated that TAM-based SMRA training increased the level of intention to use the app through targeting perceived ease of use. Furthermore, focus group findings provided guidance about how to better target perceived usefulness and positive subjective norm. Focus group findings suggested that, instead of merely introducing the technical utility of SMRA features, TAM-based SMRA training should emphasize the real-world utility of app features for participants, family members, and healthcare providers in supporting medication adherence.

For this dissertation, I utilize findings from the pilot study to modify the TAM-based SMRA training content in an attempt to better target perceived usefulness, perceived ease of use, and positive subjective norm. In addition, as the pilot study findings indicated the feasibility of TAM-based SMRA training for increasing the level of intention to use the app through targeting TAM variables, I extend the pilot study in ways that assess the utility of TAM-based SMRA training in increasing not only the level of intention to use the app but also the levels of actual app use and medication adherence (see Figure 4). Such an assessment is important to evaluate the utility of modified TAM-

based SMRA training as an intervention to promote not only app use but medication adherence. In conclusion, this dissertation is designed to assess the viability of TAM-based SMRA training in promoting app use and medication adherence, to calculate effect sizes to inform power analyses, and to evaluate its content and delivery design in preparation for a larger efficacy study.



*Figure 4.* TAM framework describing patients' progress from receiving an SMRA training to improving medication adherence using the app

### **The Aims of Dissertation and Research Questions**

Following the pilot study, the first aim of this dissertation is to assess the viability of the modified TAM-based SMRA training in targeting intention to use the app through targeting perceived usefulness of app, perceived ease of app use, and positive subjective norm regarding app use. The pilot study results indicated that TAM-based SMRA training was not helpful in targeting perceived usefulness. Focus group findings suggested that the results were attributable to the fact that the training did not introduce the real-world utility of SMRA features in supporting medication adherence. I modified the content of previous TAM-based SMRA training in ways that emphasize the real-world situations in which the SMRA features would be helpful for medication adherence

(see Dissertation Materials), and the following research question (RQ) is posed to assess its feasibility in changing the level of perceived usefulness:

**RQ1.1:** Is there a difference in perceived usefulness between before and after the modified TAM-based SMRA training?

The pilot study indicated that providing step-by-step instructions on SMRA use (as part of TAM-based SMRA training) was feasible in targeting perceived ease of use. However, I employed a posttest-only design for the pilot study and assessing the degree to which the TAM-based SMRA training influenced the change in perceived ease of use was not possible (Grove, Burns, & Gray, 2013). Therefore, the following research question is posed to assess the degree to which the modified TAM-based SMRA training is viable in changing the level of perceived ease of use:

**RQ1.2:** Is there a difference in perceived ease of use between before and after the modified TAM-based SMRA training?

The pilot study results did not indicate that TAM-based SMRA training targeted positive subjective norm. Focus group findings suggested that this was attributable to the fact that the training did not introduce the real-world utility of SMRA features for family members or healthcare providers to support participants in medication adherence. I modified the content of previous TAM-based SMRA training in ways that emphasize the real-world situations in which family members or health care providers would find participants' app use beneficial (see Dissertation Materials), and the following research question is posed to assess its feasibility in changing the level of positive subjective norm:

**RQ1.3:** Is there a difference in positive subjective norm between before and after the modified TAM-based SMRA training?

Pilot study participants who received TAM-based SMRA training reported higher level of intention to use the app than those without training. However, the degree to which the change in intention to use the app is attributable to the TAM-based SMRA training was not previously assessed due to the posttest-only design for the pilot study. Therefore, the following research question is posed to assess the degree to which the modified TAM-based SMRA training is viable in changing the level of intention to use the app:

**RQ1.4:** Is there a difference in intention to use an SMRA between before and after the modified TAM-based SMRA training?

As discussed in the rationale and literature review section, existing studies have indicated the positive relationship between SMRA use and medication adherence. If the modified TAM-based SMRA training is viable in targeting and increasing the levels of perceived usefulness, perceived ease of use, and positive subjective norm, this should increase the level of intention to use the app. Intention to use should then increase the level of app use and improve the level of medication adherence. In addition, Breau-Shropshire, Brown, Pryor, and Maples (2012) found that medication adherence self-efficacy was positively correlated with medication adherence. For this dissertation, I considered medication adherence and medication adherence self-efficacy as medication adherence variables. To assess the potential impact that the modified TAM-based SMRA training might have on medication adherence variables, the following research question is posed:

**RQ1.5:** Is there a difference in medication adherence variables (self-reported medication adherence and medication adherence self-efficacy) between before and after the modified TAM-based SMRA training?

To inform power analyses for a larger efficacy study, the second aim of this dissertation is to estimate effect size for modified TAM-based SMRA training on perceived usefulness, perceived ease of use, positive subjective norm, intention to use the app, app use, and medication adherence variables. For precise estimation, it is imperative to compare outcome variables between intervention and control groups (Noar & Head, 2011). Although I employed a two-group design for the pilot study for this dissertation, estimating effect size for TAM-based SMRA training was not possible because the sample size that was too small. Therefore, the following research questions are posed for evaluation with a larger sample size:

**RQ2.1:** Is there a difference in perceived usefulness between those with and without TAM-based SMRA training?

**RQ2.2:** Is there a difference in perceived ease of use between those with and without TAM-based SMRA training?

**RQ2.3:** Is there a difference in positive subjective norm between those with and without TAM-based SMRA training?

**RQ2.4:** Is there a difference in intention to use an SMRA between those with and without TAM-based SMRA training?

**RQ2.5:** Is there a difference in medication adherence variables (self-reported medication adherence and medication adherence self-efficacy) between those with and without TAM-based SMRA training?

Finally, again, the TAM suggests that the more the modified TAM-based SMRA training increases intention to use the app through targeting perceived usefulness, perceived ease of use, and positive subjective norm, the more likely participants are to use the app. To estimate the effect size for modified TAM-based SMRA training on app use, the following research question is posed:

**RQ2.6:** Is there a difference in SMRA use between those with and without TAM-based SMRA training?

The third aim of this dissertation is to understand ways to improve the delivery of the modified TAM-based SMRA training before embarking on a larger efficacy study. To meet this aim, it is imperative to explore participants' perceptions of SMRA training delivery components, including training format, length, location, and material. Therefore, the following research question is posed:

**RQ3:** What perceptions do participants describe in relation to SMRA training delivery?

In sum, RQ1.1-1.5 are posed to meet the first aim that is to assess the viability of the modified TAM-based SMRA training in targeting outcome variables, and RQ2.1-2.6 are posed to meet the second aim that is to estimate the effect size for modified TAM-based SMRA training on outcome variables. In addition, RQ3 is posed to meet the third aim that is to explore participants' perceptions of SMRA training delivery.



## CHAPTER THREE

### METHODS

#### **Overview**

Following the design of the pilot study, I employed a two-group design. Furthermore, to meet the aims of this dissertation, I employed a pretest-posttest and multi-method design. One group took part in training group sessions comprised of in-person modified TAM-based SMRA training, a survey conducted at three points in time, and a telephone interview (up to two hours). This group was an intervention group, and I label this group as the training group for the remainder of this dissertation. Another group took part in the non-training group session comprised of a self-SMRA navigation opportunity and a survey conducted at three points in time. This group was a control group, and I label this group as the non-training group for the remainder of this dissertation.

To meet the first and second aims of this dissertation, I conducted a survey at three different time points to assess within- and between-group differences in perceived usefulness of SMRA, perceived ease of app use, positive subjective norm regarding app use, intention to use the app, app use, and medication adherence variables. I conducted the first survey during the baseline period (before modified TAM-based SMRA training for training group and self-app navigation for non-training group), the second survey during the first follow-up period (immediately after modified TAM-based SMRA training and self-app navigation), and the third survey during the second follow-up period (one month after modified TAM-based SMRA training and self-app navigation). This study is not a randomized controlled trial and thus is subject to the threat of selection bias

(potential impacts that between-group differences in participant characteristics might have on outcome variables; Grove et al., 2013; Wrench, Thomas-Maddox, Richmond, & McCroskey, 2013). To check for possible selection effects, the first survey was used to check for significant differences in background (e.g., demographic) and outcome variables between training group and non-training group before modified TAM-based SMRA training or self-app navigation. The second survey was used to answer RQ1.1-1.4 and RQ2.1-2.4, and the third survey was used to answer RQ1.5 and RQ2.5-2.6.

To meet the third aim of this dissertation, I conducted telephone interviews with training group participants following the third survey to ascertain participants' thoughts and recommendations regarding the delivery of the modified TAM-based SMRA training. For the non-training group that did not receive the modified TAM-based SMRA training, as part of the second survey, I asked them to respond to open-ended questions to ascertain their thoughts about the potential usefulness of app training as well as their suggestions regarding the design of app training. Details regarding dissertation materials, participants, study procedures (training group and non-training group sessions), and data analysis are described in the following sections.

### **Dissertation Materials**

To meet the three aims of this dissertation, I developed three types of materials: (1) PPT slides for modified TAM-based SMRA training for training group and for self-app navigation for non-training group, (2) survey questionnaires, and (3) an interview guide for the training group. In the following sections, I describe how I developed each of these sets of materials.

### **PPT slides for modified TAM-based SMRA training for training group. I**

developed PPT slides for the modified TAM-based SMRA training for training group beginning with a brief introduction to the Medisafe<sup>®</sup> app. Following this introduction, I developed PPT slides for each section of the training: asking participants to try any SMRA features on their own for a short time, asking participants to take the first survey, targeting TAM variables, asking participants to take the second survey, informing participants of the third survey to be conducted online after one month, and recruiting volunteers for a telephone interview followed by the third survey.

The section of the training that targeted TAM variables was modified for this study based on the results of the pilot study. As discussed previously, the pilot study revealed that the previous content of the TAM-based SMRA training PPT slides was helpful in targeting perceived ease of app use and, thereby, increasing the level of intention to use the app, but not helpful in targeting perceived usefulness of app or positive subjective norm regarding app use. Because these TAM variables are also important user perceptions leading to intention to use the app, results from the pilot study were used to modify the training.

During the focus groups, after being introduced to and trying SMRA features, pilot study participants described the real-world utility of app use in medication adherence. They discussed how their specific struggles in medication adherence could be addressed using specific app features and when their family members or healthcare providers would value the app as a way to support participants in medication adherence. The pilot study participants' comments suggested that introducing the real-world utility of SMRA use in medication adherence into the training could serve as a way to target

perceived usefulness (by linking the utility of app use with addressing struggles in medication adherence in the real-world setting) and positive subjective norm (by helping participants think about the utility of app use from the perspectives of family members or healthcare providers). In this regard, I modified the content of TAM-based SMRA training PPT slides to emphasize the real-world utility of app use for participants, family members, and healthcare providers in supporting participants in medication adherence.

In the pilot study, we showed only the screenshot of the virtual pillbox and reminder features of the Medisafe<sup>®</sup> app in the PPT slides as an introduction to these app features. For the dissertation, to target perceived usefulness, I juxtaposed pilot study participants' statements about medication adherence struggles with the screenshots of the Medisafe<sup>®</sup> app features that might help address those struggles. Specifically, I quoted or reconstructed pilot study participants' statements from focus groups data (see Park et al., 2017, for specific focus groups data):

1. My bedtime one I forget a lot, just because it's, you know, it's later in the evening or whatever and I get busy and I forget that one.
2. I thought I had some left but I didn't have any left. So then it's like, ok, you gotta call your friends over at the pharmacy, and say, help!
3. If you're travelling, you know, and you're in [name of place] where the time changes so drastically ... Should I take it at, what I would have taken in [name of place] or do I switch it?
4. [I] can identify some of them, but, every few years they change ... in the last, 3 or 4 months I've, noticed that, there have been a time or two I forgot them ... They do change so often.
5. One of those things that I don't normally take, I'll write right on the bottle ... all the dates [for medication taking] ... I also tried using specific tools like pill box and Outlook calendar or setting up rules or habits like brushing teeth after medication taking ... it works but if you have a lot of them it doesn't.

I juxtaposed the first statement with a screenshot of the medication taking reminder feature of the Medisafe<sup>®</sup> app, the second statement with a screenshot of the

medication refill reminder feature, the third statement with a screenshot of the time zone support feature, and the fourth and fifth statements with a screenshot of the virtual pillbox feature. I used pilot study participants' statements in narrative format to help target perceived usefulness and intention to use an SMRA. Existing studies have indicated that people are more likely to identify themselves with those using narrative messages about a health topic than those using non-narrative messages (Lu, 2013) and that health-related narrative evidence has a stronger impact on behavioral intention than statistical evidence (Zebregs, van den Putte, Neijens, & de Graaf, 2015). Considering the findings from these studies, pilot study participants' statements in narrative format might help research participants recognize the real-world utility and personal relevance of SMRA use.

In the pilot study, we tried to target positive subjective norm by showing the screenshot of Medfriend feature of the Medisafe<sup>®</sup> app in the PPT slides. For the dissertation, to target positive subjective norm, I juxtaposed pilot study participants' statements about potential family member or healthcare provider beliefs regarding app use with the screenshots of the relevant Medisafe<sup>®</sup> app features. Specifically, I quoted or reconstructed the following statements based on focus groups data (see Park et al., 2017, for specific focus groups data):

1. For loved ones too, if anything ever happens to me, they could take my phone ... if I end up in the emergency room ...
2. When you go to a doctor, they want to know, you know, what all medicines are you on. I can never remember the dosages and things like that.

I juxtaposed both statements with a screenshot of the virtual pillbox and report features of the Medisafe<sup>®</sup> app. Following the rationale above, I used pilot study participants' statements in narrative format because statements in this form might help

research participants agree with that their family members or healthcare providers would approve of SMRA use.

To target perceived ease of use, I followed the materials used in the pilot study. Specifically, the PPT slides included screenshots of the Medisafe® app in a step-by-step manner to train participants to set up app accounts, set up the virtual pillbox with their medications added, and schedule and respond to medication-taking reminders.

In addition, following our procedures in the pilot study, I juxtaposed step-by-step screenshots of the Medisafe® app for iPhone with those for Android phone, considering the difference in the layout of the app between the two phones. Between the pilot study and the dissertation study period, Medisafe Inc. has changed the layout of Medisafe® app (e.g., icon shape), and I updated PPT slides with the screenshots of the current app as needed.

Pilot study participants (1) reported struggles in editing medication information on the Medisafe® app and (2) found medication refill reminder feature to be useful. Thus, for the dissertation, I added screenshots of the Medisafe® app in a step-by-step manner to train participants to (1) edit medication information on the app and reschedule medication-taking reminders and (2) set up and respond to a medication refill reminder.

**PPT slides for self-SMRA navigation for non-training group.** I developed the PPT slides for self-SMRA navigation for the non-training group beginning with a brief introduction regarding what the Medisafe® app is. Following this introduction, I developed the PPT slides in the following sequence: asking participants to try any SMRA features on their own for a short time, asking participants to take the first survey, asking participants to try any SMRA features on their own (without step-by-step instructions on

how to use app features) for a longer time (self-app navigation), asking participants to set up app accounts, asking participants to take the second survey, informing participants of third and online survey at one month after the self-SMRA navigation. To help participants set up app accounts, I juxtaposed step-by-step screenshots of the Medisafe<sup>®</sup> app for iPhone with those for Android phone in the PPT slides.

**Survey questionnaires.** I developed the first survey to measure TAM variables (perceived usefulness of SMRA, perceived ease of app use, positive subjective norm regarding app use), intention to use the app, medication adherence variables (self-reported medication adherence and medication adherence self-efficacy), demographic variables, and eHealth technology use variables (health-related smartphone use and Medisafe<sup>®</sup> app use self-efficacy). To conduct the first survey before the in-person modified TAM-based SMRA training (for the training group) and the self-app navigation presentation (for non-training group), I developed the first survey in a paper-and-pencil questionnaire format.

I developed the second survey to measure TAM variables and intention to use an SMRA, as well as to record participants' email addresses for the distribution of a link to an online and third survey. To conduct the second survey immediately after in-person modified TAM-based SMRA training and self-app navigation, I developed the second survey in a paper-and-pencil questionnaire format. For non-training group, I also developed an online version of the second survey for participants to complete (see Non-training group session).

I developed the third survey to measure medication adherence variables, perceived impact of the app training variable (for training group only), and self-reported

Medisafe<sup>®</sup> app use, as well as to record participants' email addresses in order to link the second survey and third survey data. The third survey was administered one month after in-person modified TAM-based SMRA training and self-app navigation with an online questionnaire format.

### ***First survey measurement***

*Perceived usefulness.* Perceived usefulness was measured using six items adapted from the pilot study for this dissertation (Park et al., 2017). In the pilot study, we adapted Davis's (1989) six items for the measurement of perceived usefulness of SMRA. For the dissertation, after discussion with my advisory committee members, I revised the following items:

- Using the Medisafe<sup>®</sup> app would help me to better manage and keep track of my medications.
- Using the Medisafe<sup>®</sup> app would help me to remember to take my medications.
- Using the Medisafe<sup>®</sup> app would make it easier to manage and keep track of my medications.
- I would find the Medisafe<sup>®</sup> app to be useful in managing and keeping track of my medications.

Specifically, I revised these items in order to make the items clearer and more understandable and to assess the perceived usefulness of SMRA in supporting all adherent behavior that the modified TAM-based SMRA training is designed to target. Revised items are:

- Using the Medisafe<sup>®</sup> app would help me to better track what medications I should refill.



- Using the Medisafe® app would help me to remember to take my medications at the right time.
- Using the Medisafe® app would make it easier to track whether I have taken my medications or not.
- I would find the Medisafe® app to be useful in tracking that I am taking medications as prescribed.

On a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*), participants were asked to report the degree to which they agree with statements such as “Using the Medisafe® app would help me quickly check what medications I should take.” Item scores were summed and averaged to create a perceived usefulness scale that ranged from 1.00 to 7.00 ( $M = 5.64$ ,  $Mdn = 5.92$ ,  $SD = 1.36$ ). Cronbach’s alpha was calculated to assess the reliability of the perceived usefulness scale, and the score on the scale ( $\alpha = .96$ ) was deemed acceptable.

*Perceived ease of use.* Perceived ease of use was measured using six items adapted from Davis’s (1989) study and pretested through the pilot study for this dissertation ( $\alpha = .99$ ; Park et al., 2017). On a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*), participants were asked to report the degree to which they agree with statements such as “It was easy for me to become skillful at using the Medisafe® app.” Item scores were summed and averaged to create a perceived ease of use scale that ranged from 1.00 to 7.00 ( $M = 5.62$ ,  $Mdn = 5.92$ ,  $SD = 1.41$ ). Cronbach’s alpha indicated acceptable reliability of perceived ease of use scale ( $\alpha = .96$ ).

*Subjective norm.* Subjective norm was measured using seven items adapted from Charng, Piliavin, and Callero’s (1988) study and pretested through the pilot study for this

dissertation ( $\alpha = .88$ ; Park et al., 2017). On a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*), participants were asked to report the degree to which they agree with statements such as “They would think that using the Medisafe® app is important to me.” Item scores were summed and averaged to create a subjective norm scale that ranged from 2.14 to 6.14 ( $M = 4.21$ ,  $Mdn = 4.00$ ,  $SD = 1.01$ ). Higher scale score indicated higher and more positive level of subjective norm. Cronbach’s alpha indicated acceptable reliability of subjective norm scale ( $\alpha = .80$ ).

*Intention to use an SMRA.* Intention to use an SMRA was measured using three items adapted from Venkatesh, Morris, Davis, and Davis (2003) and Magsamen-Conrad, Upadhyaya, Joa, and Dowd’s (2015) studies and pretested through the pilot study for this dissertation ( $\alpha = .97$ ; Park et al., 2017). On a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*), participants were asked to report the degree to which they agree with statements such as “I intend to use the Medisafe® app in the next 3 months.” Item scores were summated and averaged to create an intention to use an SMRA scale that ranged from 2.00 to 7.00 ( $M = 5.81$ ,  $Mdn = 6.00$ ,  $SD = 1.20$ ). Cronbach’s alpha score indicated acceptable reliability of intention to use an SMRA scale ( $\alpha = .98$ ).

*Medication adherence variables.* Medication adherence variables consisted of self-reported medication adherence and medication adherence self-efficacy. Self-reported medication adherence was measured using items from previous studies (Bartlett Ellis, Ganci, Head, & Ofner, 2018; Voils et al., 2012). On a 5-point Likert-type scale (1 = *strongly disagree* to 5 = *strongly agree*), participants were asked to report the degree to which they agree with item statements from Voils et al.’s (2012) Extent of Medication

Nonadherence scale, such as “[over the past 7 days] I took all doses of my prescribed medication” (reverse-coded) and “I missed or skipped at least one dose of my prescribed medication.” The original scale consists of three items but the third item (“I was not able to take all of my prescribed medication”) was excluded from data analysis in order to strengthen the reliability of medication adherence scale ( $\alpha = .91$  with item deleted). The two remaining item scores were summed and averaged to create a medication adherence scale that ranged from 1.00 to 5.00 ( $M = 2.29$ ,  $Mdn = 1.50$ ,  $SD = 1.39$ ) with lower scores indicating higher levels of medication adherence.

Because I decided to use two items to create a medication adherence scale, following previous research procedure (Stephens et al., 2015; Zarski et al., 2018), I calculated the Spearman-Brown coefficient recommended to assess the reliability of two-item scales (Eisinga, te Grotenhuis, & Pelzer, 2013). The reliability of the medication adherence scale was deemed acceptable (Spearman-Brown coefficient = .91).

On a 5-point Likert-type scale (1 = *never/rarely* to 5 = *always*), participants were asked to answer one question from Bartlett Ellis et al.’s (2018) study, “people who take medications report trouble remembering to take their medications. How often do you have trouble remembering to take all your medications?” Lower score indicated higher level of medication adherence.

In addition, following Bartlett Ellis et al. (2018), participants were asked “when do you refill your prescription with five alternative responses provided (*when I run out, a couple days before I run out, a couple days after I have run out, it varies, sometimes I go a few days without taking my medications*). Participants who reported “when I run out” or “couple days before I run out” were classified as “timely refill” participants. Participants

who reported “a couple days after I have run out” (there was no participant who reported “sometimes I go a few days without taking my medications”) were classified as “late refill” participants.

Medication adherence self-efficacy was measured using 13 items adapted from the revised medication adherence self-efficacy scale (MASES-R; Fernandez, Chaplin, Schoenthaler, & Ogedegbe, 2008). On a 4-point Likert-type scale (1 = *not at all sure* to 4 = *extremely sure*), participants were asked to report the degree to which they agree with MASES-R item statements including “How confident are you that you can take your medications when you are busy at home?” Item scores were summed and averaged to create a medication adherence self-efficacy scale that ranged from 1.77 to 4.00 ( $M = 3.16$ ,  $Mdn = 3.23$ ,  $SD = 0.66$ ). Cronbach’s alpha indicated acceptable reliability of medication adherence self-efficacy scale ( $\alpha = .93$ ).

I originally considered using the MMAS-8 (Morisky et al., 2008) and MMAS-4 (Morisky et al., 1986) to measure self-reported medication adherence and contacted Dr. Morisky to ask for permission to use these scales. However, I was informed that such a permission can be given to organizations (e.g., university) upon the completion of MMAS training but is not given to individuals. Thus, the use of MMAS-4 and MMAS-8 was not feasible for this dissertation.

In addition, I originally planned to also conduct an objective measurement of medication adherence by collecting participants’ pharmacy claim data and calculating medication possession ratio (MPR) using the following formula (Andrade, Kahler, Frech, & Chan, 2006; Lofland et al., 2017):  $MPR (\%) = \frac{\text{the number of days a participant was prescribed to take medications within the dissertation study period (excluding the last$

refill date)/the number of days between the first refill date and the last refill date within the dissertation study period  $\times 100$  (higher percentage indicates higher level of medication adherence). I contacted one company to ask if I could recruit participants for this research among those included in the company's pharmacy claim data set and assess the difference in MPR between the training and non-training groups. However, I was informed that such a plan was not feasible, because the pharmacy claim data set was too costly to be used for this self-funded dissertation and there was no identifying information in the data set to be used for participant recruitment.

*eHealth technology use variables.* Health-related smartphone use experience and health information technology use self-efficacy (e.g., Internet, app) have been positively associated with perceived ease of use (Cho, Quinlan, et al., 2014; Dou et al., 2017). For this dissertation, I considered health-related smartphone use experience and Medisafe<sup>®</sup> app use self-efficacy as eHealth technology use variables. As discussed in the overview of the methods section, I measured these eHealth technology use variables to assess whether or not the selection effect might exist for the dissertation.

Health-related smartphone use was measured using nine items from or adapted from existing literature (Ernsting et al., 2017; Fox & Duggan, 2013). Using dichotomous responses (1 = *yes* and 0 = *no*), participants were asked to answer questions such as “(Think about the last 12 months. Did you use smartphone apps ...) to maintain a healthy diet?” Based on Ernsting et al.'s (2017) research procedure, participants who reported “yes” to at least one question were classified as health-related smartphone users. In contrast, participants who did not report “yes” to any of questions were classified as non-users.

Medisafe<sup>®</sup> app use self-efficacy was measured using ten items adapted from a computer self-efficacy scale (Compeau & Higgins, 1995). On a 7-point Likert-type scale (1 = *not at all confident* to 7 = *totally confident*), participants were asked to report the degree to which they agree with statements such as “(I could use the Medisafe<sup>®</sup> app ...) if someone else had helped me get started.” Item scores were summed and averaged to create a Medisafe<sup>®</sup> app use self-efficacy scale that ranged from 4.20 to 7.00 ( $M = 6.04$ ,  $Mdn = 6.05$ ,  $SD = 0.86$ ). Cronbach’s alpha indicated acceptable reliability of Medisafe<sup>®</sup> app use self-efficacy scale ( $\alpha = .89$ ).

In addition, demographic (e.g., age, gender, race and ethnicity, income level, education level) and clinical (e.g., type of chronic condition, number of chronic condition, number of medication) variables have been associated with medication adherence (Kirkman et al., 2015; Rolnick et al., 2013). As discussed in the overview of the methods section, I measured demographic variables to assess the possibility of a selection effect.

***Second survey measurement.*** Participants were asked to complete a survey questionnaire measuring perceived usefulness, perceived ease of use, subjective norm, and intention to use an SMRA. These variables were measured using the methods described above. Item scores were summed and averaged to create a perceived usefulness scale that ranged from 2.67 to 7.00 ( $M = 6.22$ ,  $Mdn = 6.50$ ,  $SD = 1.01$ ), a perceived ease of use scale that ranged from 3.17 to 7.00 ( $M = 6.19$ ,  $Mdn = 6.75$ ,  $SD = 1.07$ ), a subjective norm scale that ranged from 1.57 to 6.57 ( $M = 4.07$ ,  $Mdn = 4.14$ ,  $SD = 1.07$ ), and an intention to use an SMRA scale that ranged from 1.33 to 7.00 ( $M = 5.82$ ,  $Mdn = 6.00$ ,  $SD = 1.39$ ). Cronbach’s alphas indicated acceptable reliability of the perceived

usefulness scale ( $\alpha = .95$ ), the perceived ease of use scale ( $\alpha = .96$ ), the subjective norm scale ( $\alpha = .82$ ), and the intention to use an SMRA scale ( $\alpha = .95$ ).

In addition, participants were asked to leave their email addresses at the end of the questionnaire. This information was needed for the distribution of a link to an online and third survey one month after in-person modified TAM-based SMRA training and self-app navigation.

For the non-training group only, I asked participants to answer additional open-ended questions about: (1) their perceptions of Medisafe<sup>®</sup> app in relation to TAM variables; (2) how they figured out how to use app features (e.g., use of online app training video, discussion with other participants, self-app navigation); and (3) their opinions on and suggestions for app training.

### ***Third survey measurement and SMRA usage data collection***

*SMRA use.* SMRA use was assessed using self-report and app usage data the Medisafe Inc. collected and shared with me. For the self-report measurement, on a 6-point Likert-type scale (1 = *don't use at all* to 6 = *always use to take prescribed medications*), participants were asked to answer a question adapted from previous studies (for response options, Davis, 1989; for question statement, Venkatesh & Davis, 2000), “How often do you use Medisafe<sup>®</sup> app to take your prescribed medications?”

As an objective measurement of SMRA use, I collected participants' one-month Medisafe<sup>®</sup> app usage data in cooperation with Medisafe Inc. To assess how many training and non-training group participants continued or discontinued Medisafe<sup>®</sup> app use during one month after in-person modified TAM-based SMRA training and self-app navigation, I used the data indicating the first and last date the participants took medication using the

app. To avoid additional reminders for medications already taken, a Medisafe<sup>®</sup> app user should immediately respond to the medication taking reminder by opening the app and tapping “take” on the reminder message. The Medisafe<sup>®</sup> app then records the time the user tapped “take” and does not send additional reminders.

For each participant ID (not personally identifiable) data, if there was a record of at least one medication that the participant took using the app for a month (one-month interval between the first and last dates tapping “take”), I considered the participant as a “one month” (and more active) user. Otherwise, I considered the participant as a “less than a month” (and less active) user.

To distinguish training group data from non-training group data, Medisafe Inc. provided me with two group codes. I asked participants to make a group code (one code for training group and another code for non-training group) request of Medisafe Inc. as part of setting up their app accounts on the Medisafe<sup>®</sup> app. Medisafe Inc. then checked their database and classified participants’ data as training group data or non-training group data based on the code assigned to them. I was able to collect one-month Medisafe<sup>®</sup> app usage data for seven (three iPhone users and four Android phone users) of 15 training group participants and five (all Android phone users) of 14 non-training group participants. Other participants’ data were not available due to a technical issue (i.e., the group code requests were not traceable).

*Medication adherence variables.* Medication adherence variables were measured using method described above. Item scores were summed and averaged to create a medication nonadherence scale that ranged from 1.00 to 5.00 ( $M = 2.44$ ,  $Mdn = 3.00$ ,  $SD = 1.36$ ) and medication adherence self-efficacy scale that ranged from 2.00 to 4.00 ( $M =$



3.18,  $Mdn = 3.08$ ,  $SD = 0.62$ ). The reliability of the medication adherence scale was deemed acceptable (Spearman-Brown coefficient = .69). In addition, Cronbach's alpha indicated acceptable reliability of the medication adherence self-efficacy scale ( $\alpha = .93$ ).

*Perceived impact of an SMRA training.* For the training group only, I measured perceived impact of an SMRA training to assess whether and the degree to which participants attribute their app use to receiving the app training. This variable was measured using two items adapted from Botta, Dunker, Fenson-Hood, Maltarich, and McDonald's (2008) study. On a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*), participants were asked to report the degree to which they agree with the following two statements: "the Medisafe training I had received made me think more about using the app" and "I started using the Medisafe® app because of the app training I had received." Item scores were summed and averaged to create a perceived impact of an SMRA training scale that ranged from 3.50 to 7.00 ( $M = 6.07$ ,  $Mdn = 6.50$ ,  $SD = 1.07$ ). The reliability of the perceived impact of an SMRA training scale was deemed acceptable (Spearman-Brown coefficient = .70).

**Telephone interview guide.** For training group participants only, I developed a semi-structured telephone interview guide. The interview guide begins with a statement asking participants to permit me to audio-record telephone interview for the purpose of transcription and data analysis. Following this statement, the interview guide includes questions about participants' perceptions of the Medisafe® app in relation to TAM variables (perceived usefulness, perceived ease of use, positive subjective norm), perceptions of modified TAM-based app training as an introductory course in app use (e.g., how comfortable the participants felt about using the app after modified TAM-

based app training), and a request for suggestion regarding the design of modified TAM-based app training delivery for future participants, such as training content material to be added, length, and training format (e.g., face-to-face format versus online format, individual setting versus small group setting).

## **Participants**

In this section, I describe inclusion and exclusion criteria, as well as recruitment strategies and procedures. Participant recruitment was the biggest challenge for this dissertation, and inclusion and exclusion criteria, and recruitment strategies and procedures were adjusted as needed to facilitate recruitment.

**Inclusion and exclusion criteria.** Inclusion criteria for this dissertation were patients who are outpatients, are 40 or older, have been managing a chronic condition with at least three prescribed medications for at least three months, are iPhone or Android users but have no experience with smartphone medication reminder app use. Exclusion criteria were patients with limited English proficiency, who are inpatients, are younger than 40, do not use smartphones, cannot travel to the study location, or are taking antipsychotic medications (e.g., patients with schizophrenia).

I experienced difficulty in participant recruitment and discussed these challenges with my advisor. I decided to adjust the following inclusion criteria. First, regarding the inclusion criterion, “managing a chronic condition with at least three prescribed medications for at least three months,” I decided to allow participants as long as they take a medication (e.g., a prescribed medication, vitamin, or supplement) to manage a chronic condition. In doing so, I was able to recruit two participants taking one prescribed medication and one participant taking vitamins to manage chronic condition. Regarding

the inclusion criterion, “no experience with smartphone medication reminder app use,” I decided to allow participants as long as they have no experience with Medisafe® app use. In doing so, I was able to recruit one participant who reported using other medication app different from the Medisafe® app. In addition, I removed the exclusion criterion, “not taking antipsychotic medications,” and, in doing so, I was able to recruit one participant taking antipsychotic medications but meeting all inclusion criteria.

**Recruitment.** This dissertation is the first study to estimate intervention effect size to inform power analyses for a larger efficacy study. Considering a sample size that Hertzog (2008) and Julious (2005) suggested as sufficient to estimate intervention effect sizes (ten per group and twelve per group, respectively), I recruited 15 training group participants and 14 non-training group participants.

After I obtained approval for the study from the university’s institutional review board (IRB), I started participant recruitment with support from a healthcare provider in a Midwestern hospital. I asked the healthcare provider to share study information and recruitment flyer with other healthcare providers or those who met the inclusion criteria and might be interested in this research. In doing so, I expected that those who met the inclusion criteria and were interested in the study would personally contact me. However, I ended up recruiting no participants using this strategy. In addition, I posted a recruitment message on Facebook. Using this strategy, I was able to recruit three training group participants. However, except for these participants, I was not able to make further progress in recruitment.

Through discussion with my advisory committee members, I decided to use more active and varied recruitment strategies. After I obtained approval for an amended

participant recruitment plan from the university's IRB, I distributed recruitment flyers to a Midwestern hospital and posted it on public bulletin boards throughout the Midwestern university campus (as well as Facebook). I also engaged in in-person recruitment on the Midwestern university campus (e.g., campus center) and at community sites (e.g., my apartment, church, senior citizen center), and offered a gift card incentive to participants. With these methods, I was able to recruit 12 additional (a total of 15) training group participants and 14 non-training group participants.

### **Study Procedures**

In this section, I describe how I conducted the training group sessions and non-training group session (see Table 1). For the pilot study, we were able to recruit participants from one Midwestern hospital with support from a hospital staff member and able to conduct the study at that hospital on two different dates (one date for the training group and another date for the non-training group).

For the dissertation, however, participant recruitment from and scheduling training and non-training group sessions on two different dates at one hospital were not feasible. Instead I recruited participants at different times and from different channels. I assigned 15 participants to the training group, and I met them for modified TAM-based SMRA training on seven different dates and eight different times at their convenience. In other words, I divided the training group sessions for 15 participants into eight meetings (four meetings with single participants, two meetings with two-participant groups, one meeting with a three-participant group, and one meeting with a four-participant group). My advisor and I agreed that this was feasible, as the focus of the dissertation is on the

content of the modified TAM-based SMRA training, not the training format (i.e., individual or group).

I was able to recruit 14 non-training group participants attending the same church with support from my advisor. Therefore, I was able to schedule and conduct a single non-training group session.

I conducted training and non-training group sessions in private rooms at a Midwestern university or at community sites. For participants at the university, I provided a campus map along with information about where to park and meet and parking fee as needed. I provided participants with \$20 Walmart gift card for taking part in the study.

**Training group session.** As mentioned previously, I conducted the training group sessions on seven different dates and eight different times at a private room in Midwestern university, restaurant, or apartment at participants' convenience. After obtaining informed consent, I asked participants to download the Medisafe® app to their smartphones. After the participants downloaded the app to their smartphones, I asked them to try any app features on their own for up to five minutes. Next, I asked participants to complete the first survey. Following the first survey, I provided participants with modified TAM-based SMRA training designed to target perceived usefulness of app, perceived ease of app use, and positive subjective norm regarding app use.

To target perceived usefulness, I read the first pilot study participant statement above (see PPT slides for modified TAM-based SMRA training for training group) and introduced the medication-taking reminder feature. I read the second pilot study

participant statement and introduced the medication refill reminder feature. I read the third pilot study participant statement and introduced the time zone support feature that helps participants take their medications on time when traveling to places with a different time zone. Then, I read the fourth and fifth pilot study participant statements and introduced the virtual pillbox feature that helps participants remember when and what exact medications they should take by showing medication icons and identifying information such as medication name and dosage.

To target positive subjective norm, I read the first pilot study participant statement and introduced the virtual pillbox and report features (medication adherence record) that participants' family members could find helpful when explaining what medications participants are on to healthcare providers in the emergency care setting. In addition, I read the second pilot study participant statement and introduced the virtual pillbox and report features that healthcare providers could find helpful when checking what medications participants are on and whether they have taken medications as prescribed (during routine medical checkups or medication reconciliation). After I completed the training sections targeting perceived usefulness and positive subjective norm, I talked informally with participants about other situations in which the app might be useful.

To target perceived ease of use, I provided participants with step-by-step instructions on how to set up app accounts, how to set up the virtual pillbox with their medications added, how to schedule and respond to medication taking reminders, how to edit medication information on the app and reschedule medication taking reminders, and how to set up and respond to medication refill reminders.

Next, I asked participants to complete the second survey. In addition, I informed participants of the third (online) survey one month after the modified TAM-based SMRA training and asked them to volunteer for a telephone interview following that survey. One month after the modified TAM-based SMRA training, I asked participants to complete the third (online) survey and then conducted telephone interviews with participants. Considering the interview sample size that Tracy (2013) and Guest, Bunce, and Johnson (2006) suggest as enough for data analysis (five to eight interviewees and six to twelve interviewees, respectively), I conducted telephone interviews with 14 of 15 participants.

I recorded the telephone interviews with participants' permission for the purpose of transcription and data analysis. I transcribed the audio-recorded telephone interviews using a transcription service and checked the accuracy of the transcripts. Transcripts included vocal fillers, but I removed them as needed for ease of reading. In addition, I replaced participant names with pseudonyms. The interviews lasted between nine minutes and 18 minutes, with an average length of 13 minutes. The training group sessions were completed with the completion of the telephone interview.

**Non-training group session.** I conducted the first parts of the non-training group session (self-app navigation with first and second survey) at a private room in the church where the participants were member. The session took place on a Sunday morning after the service. After obtaining informed consent, I asked participants to download the Medisafe® app to their smartphones. Participants started downloading the app to their smartphones, and I asked them to try any app features on their own for up to 5 minutes. Next, I asked participants to complete the first survey. Following the first survey, I asked participants to further self-navigate app features.

As they were doing this, I helped individual participants set up app accounts using a group code (that Medisafe Inc. provided for the purpose of app usage data collection). Helping them as a group was not feasible as participants differed in their speed in setting up app accounts, and their smartphones differed in terms of download speed.

I was given one hour for the first parts of the non-training group session. Following the first survey, I had to spend the rest of that hour helping individual participants set up app accounts. As a result, I was not able to ask participants to complete the paper-and-pencil version of the second survey at that time.

I instead asked participants to complete the online version of the second survey later, and 11 of 14 participants completed the second survey 2-13 days after self-app navigation. One month after self-app navigation, I asked participants to complete the third (online) survey. The non-training group session was completed with the completion of the third survey.

## **Data Analysis**

**Quantitative data analysis.** To meet the first and second aims, I used SPSS 16.0 (SPSS Inc.) to analyze the quantitative data. Following previous practice and suggestion from existing literature (Grove et al., 2013; Khetani, Lim, & Corden, 2017), I conducted Shapiro-Wilk's *W* tests to see if the assumption for normal distribution of the data was met. Next, I conducted chi-square tests and independent samples *t*-tests or Mann-Whitney *U* tests (as a nonparametric alternative if the data were not normally distributed) to assess whether there were differences in background and outcome variables between the training and non-training groups at baseline (before modified TAM-based SMRA training and self-app navigation).



To answer the research questions, first I conducted McNemar tests and paired *t*-tests or Wilcoxon signed-rank tests (as a nonparametric alternative) to assess within-group differences in outcome variables (RQ1.1-1.5). Second, I conducted chi-square tests and independent *t*-tests or Mann-Whitney *U* tests (as a nonparametric alternative) to assess between-group differences in outcome variables (RQ2.1-2.6).

The use of multiple statistical tests is subject to type I error, and the Bonferroni correction is suggested as a way to reduce the risk of type I error (Armstrong, 2014). However, the Bonferroni correction with the small sample size of this dissertation might result in type II error (Armstrong, 2014; Beiwinkel et al., 2016), leading to underestimating the viability of modified TAM-based SMRA training in influencing outcome variables. Because this dissertation was designed to assess the viability (not efficacy) of the modified TAM-based SMRA training, and because the Bonferroni correction is called for when ascertaining causal relationships, I did not conduct Bonferroni correction.

Following previous research (Fletcher et al., 2019; Vyas, Landry, Schnider, Rojas, & Wood, 2012), I used pairwise deletion method to handle missing data (Shapiro-Wilk's *W* test, independent *t*-test, Mann-Whitney *U* test, paired *t*-test, and Wilcoxon signed-rank test). For data analyzed using parametric test, effect size was expressed as Cohen's *d*. For data analyzed using nonparametric test, effect size was expressed as *r* value:  $r = \sqrt{z^2/N}$  (Rosenthal, 1991) that is equivalent to  $r = z/\sqrt{N}$  (Ellis, 2010; Rosenthal, 1991, 1994).

**Qualitative data analysis.** To meet the third aim, I analyzed telephone interview transcripts (data from training group) and responses to open-ended questions (data from non-training group) to identify themes about participants' opinions and suggestions

regarding the design of SMRA training delivery. In addition to this third aim-related data, I analyzed qualitative data to ascertain themes about participants' perceptions of SMRA and app training in relation to TAM variables (potential supplemental data for the first and second aims). To analyze qualitative data, I conducted the first- and second-level coding using constant comparative methods (Tracy, 2013).

During the first-level coding, I carefully read telephone interview transcripts and responses to open-ended questions and highlighted individual participant statements relevant to SMRA training delivery. During the second-level coding, I categorized highlighted statements into themes such as training format (e.g., small group training format and individual training format), material, and length. For example, I categorized participant statements such as “it was bit longer” and “I think the two hours was just about the right length of time” (that I highlighted during the first level coding) into “training length” theme. In addition, through the constant comparative method, I iteratively read and compared participant statements within each theme and modified the name of that theme as needed in a way that better reflects suggestion for better SMRA training delivery. For example, as the abovementioned participant statements indicate, participants suggested that SMRA training length is individualized (taking account of the amount of training time the participants can allot and need to learn about the app), rather than being fixed, indicating that they differed in their opinions regarding whether SMRA training length was long or short. Considering this, I changed the name “training length” to “tailoring training length to participant preference” so that the theme could better describe one of suggestions for better SMRA training delivery. Second-level coding revealed six themes.

I was the only coder and thus may be subject to subjectivity or bias in coding (Goering, 2015). Using multiple coders and obtaining participant feedback to validate the themes could have been helpful in minimizing bias in qualitative data coding (Goering, 2015; Park et al., 2017). However, because the third aim of this dissertation was to obtain opinions and suggestions for better SMRA training delivery in the future, and because I collected the qualitative data about SMRA training delivery in a non-leading manner and coded and interpreted data in a neutral manner, I felt comfortable relying on a single coder.

Table 1

*Group Session Sequences*

Group		Baseline			Group Activity		First Follow-Up	Second Follow-Up
Training Group	Informed consent process	Participants asked to download the Medisafe® app to their smartphones	Brief introduction of Medisafe® app	Participants asked to try any app features for 5 minutes	First survey	Modified TAM-based Medisafe® app training	Second survey	Third survey and telephone interview
Non-Training Group	Informed consent process	Participants asked to download the Medisafe® app to their smartphones	Brief introduction of Medisafe® app	Participants asked to try any app features for 5 minutes	First survey	Self-Medisafe® app navigation	Second survey	Third survey

## CHAPTER FOUR

### RESULTS

In this chapter, I first report participant characteristics. Then, I report findings for research questions related to the first and second aims of this dissertation, followed by findings for the research question relevant to the third aim of this dissertation.

#### **Participant Characteristics**

Of the 28 participants (one non-training group participant who did not complete any of three surveys was excluded from data analysis), 54% (15/28) were part of the training group and 46% (13/28) were a part of the non-training group. Of the 28 participants, 54% (15/28) were female and 46% (13/28) were male. Participants' ages ranged from 43 to 77 years ( $M = 62$ ,  $SD = 8.80$ ). The majority of participants were white (82%, 23/28) and reported income levels of "comfortable" (79%, 22/28). The majority of participants reported education levels of some college or higher (86%, 24/28). All but one participant reported they had never used an SMRA before.

For age, education, income, number of prescribed medications, and number of other medications (e.g., vitamins, supplements, etc.) that are ordinal or higher level variables, I conducted Shapiro-Wilk's  $W$  tests with pairwise deletion method to assess if they met the assumption for normal distribution. Results revealed that all but age ( $p = .69$ ) were not normally distributed.

I therefore conducted independent samples  $t$ -test to assess if there was a significant difference in age between training group and non-training group. Levene's test for equality of variances was not significant ( $F = 0.17$ ,  $p = .68$ ), so equality of variances was assumed:  $t(26) = -2.11$ ,  $p < .05$ . Non-training group participants ( $M = 65$ ,  $SD = 7.51$ )

were significantly older than training group participants ( $M = 59$ ,  $SD = 8.89$ ). Chi-square tests and Mann-Whitney  $U$  tests revealed that there were no significant differences in other demographic variables between training and non-training groups (see Table 2).

Table 2

*Demographic Profile of the Participants*

Demographics	Training Group ( $n = 15$ )	Non-Training Group ( $n = 13$ )	$p^{ab}$
<b>Age, <math>M</math> (<math>SD</math>)</b>	59 (8.89)	65 (7.51)	< .05 <sup>a</sup>
<b>Gender, <math>n</math> (%)</b>			.98 <sup>b</sup>
Female	8 (53)	7 (54)	
Male	7 (47)	6 (46)	
<b>Ethnicity, <math>n</math> (%)</b>			.82 <sup>b</sup>
Non-Hispanic or Latino	14 (93)	10 (77)	
Unknown or do not want to report	1 (7)	1 (8)	
<b>Race, <math>n</math> (%)</b>			.053 <sup>b</sup>
Black or African American	4 (27)	0 (0)	
White	11 (73)	12 (92)	
<b>Education, <math>n</math> (%)</b>			.47 <sup>c</sup>
High school diploma or GED	2 (13)	2 (15)	
Some college	3 (20)	2 (15)	
Associate's (2-year) degree	2 (13)	0 (0)	
Bachelor's (4-year) degree	4 (27)	3 (23)	
Post-bachelor's degree	4 (27)	6 (46)	
<b>Income, <math>n</math> (%)</b>			.62 <sup>c</sup>
Comfortable	11 (73)	11 (85)	
Having just enough to make ends Meet	4 (27)	2 (15)	
<b>Experience with SMRA use, <math>n</math> (%)</b>			.27 <sup>b</sup>
Yes	0 (0)	1 (8)	
No	15 (100)	12 (92)	
<b>Phone, <math>n</math> (%)</b>			.41 <sup>b</sup>
iPhone	11 (73)	7 (54)	
Android	4 (27)	5 (39)	

*Note.* All but one participant reported another SMRA (different from the Medisafe<sup>®</sup> app).

<sup>a</sup> $p$  values calculated using independent samples  $t$ -test. <sup>b</sup> $p$  values calculated using chi-square tests. <sup>c</sup> $p$  values calculated using Mann-Whitney  $U$  tests.

(continued)

Table 2

*Demographic Profile of the Participants*

Demographics	Training Group ( <i>n</i> = 15)	Non-Training Group ( <i>n</i> = 13)	<i>p</i> <sup>ab</sup>
<b>Chronic condition, <i>n</i> (%)</b>			
Anemia or other blood disease	1 (7)	2 (15)	.46 <sup>a</sup>
Arthritis	5 (33)	5 (39)	.78 <sup>a</sup>
Asthma	2 (13)	1 (8)	.63 <sup>a</sup>
Back pain	7 (47)	4 (31)	.39 <sup>a</sup>
Depression	1 (7)	1 (8)	.92 <sup>a</sup>
Diabetes	0 (0)	1 (8)	.27 <sup>a</sup>
Epilepsy	0 (0)	1 (8)	.27 <sup>a</sup>
Heart disease	2 (13)	3 (23)	.50 <sup>a</sup>
High blood pressure	10 (67)	8 (62)	.78 <sup>a</sup>
High cholesterol	0 (0)	1 (8)	.27 <sup>a</sup>
Kidney disease	0 (0)	2 (15)	.12 <sup>a</sup>
Liver disease	1 (7)	0 (0)	.34 <sup>a</sup>
Obesity	2 (13)	0 (0)	.17 <sup>a</sup>
Sleep apnea	1 (7)	0 (0)	.34 <sup>a</sup>
Thyroid disease	1 (7)	1 (8)	.92 <sup>a</sup>
Ulcer or stomach disease	3 (20)	2 (15)	.75 <sup>a</sup>
<b>Prescribed medication, <i>n</i> (%)</b>			.11 <sup>b</sup>
1	3 (20)	1 (8)	
2	0 (0)	2 (15)	
3	6 (40)	0 (0)	
4	3 (20)	3 (23)	
5	1 (7)	1 (8)	
6	1 (7)	0 (0)	
7	0 (0)	1 (8)	
8	0 (0)	2 (15)	
9	1 (7)	2 (15)	
<b>Other medication, <i>n</i> (%)</b>			.39 <sup>b</sup>
0	6 (40)	3 (23)	
1	1 (17)	1 (8)	
2	3 (20)	2 (15)	
3	1 (7)	4 (31)	
4	1 (7)	0 (0)	
6	1 (7)	1 (8)	

<sup>a</sup>*p* values calculated using chi-square tests. <sup>b</sup>*p* values calculated using Mann-Whitney *U* tests

### **Aim 1. Assessment of the Viability of the Modified TAM-Based SMRA Training**

The first aim of this dissertation was to assess the viability of the modified TAM-based SMRA training and, it was assessed through research questions 1.1 to 1.5 that considered perceived usefulness of SMRA, perceived ease of app use, positive subjective norm regarding app use, intention to use the app, and medication adherence variables before and immediately after the training.

For perceived usefulness, perceived ease of use, positive subjective norm, intention to use an SMRA, the medication adherence scale, the medication adherence item, and medication adherence self-efficacy, I first conducted Shapiro-Wilk's  $W$  tests with pairwise deletion (for training group data only) to assess if they meet the assumption for normal distribution. Results revealed that all but medication self-efficacy for the first and third survey ( $p = .51$  and  $p = .25$ , respectively) were not normally distributed. Thus, For RQ1.1-1.5, I conducted Wilcoxon signed-rank tests for non-normally distributed variable data. In addition, for RQ1.5 only, I conducted the McNemar test for medication refill item data that classified participants as either "timely refill" or "late refill" participants. For RQ1.5, I also conducted paired  $t$ -test for normally distributed medication adherence self-efficacy data. The results of these tests are presented in Table 3.

**Research question 1.1.** Is there a difference in perceived usefulness between before and after the modified TAM-based SMRA training? RQ1.1 was to assess if there is a difference in perceived usefulness between before and after the modified TAM-based SMRA training. As mentioned previously, TAM proposes perceived usefulness as a determinant of intention to use an SMRA (the more useful the people think using the app is to support medication adherence, the more likely they are to intend to use the app).



Assessing the viability of the modified TAM-based SMRA training in targeting (or increasing the level of) perceived usefulness is therefore important to assess the viability of the training in increasing the level of intention to use the app.

Wilcoxon signed-rank test revealed that there was a significant difference in the level of perceived usefulness:  $z = -2.94, p < .01$ . Training group participants reported higher level of perceived usefulness immediately after the modified TAM-based SMRA training ( $Mdn = 7.00$ ) than before the training ( $Mdn = 5.67$ ).

Qualitative data appeared to support this finding, revealing that modified TAM-based SMRA training content designed to target perceived usefulness corresponded with training group participants' descriptions of perceived usefulness. For example, the modified TAM-based SMRA training content included the introduction of the real-world utility of SMRA in supporting medication taking and refilling on time. One month after modified TAM-based SMRA training, Kevin appeared to agree with the utility of the app regarding taking medication on time, saying, "you know that you have taken your pill 'cause that [SMRA] reminded whereas tryin' to do it from your own memory, sometimes it's, well, did I take it or not?" Edward also supported this function, saying, "I have it programmed at 7:30 in the morning, which is the time I'm usually in my car, which is where I keep my medicine. [...] it certainly reminds me to take it if I have not [taken it]." Similarly, Michael stated that "the app showed me that I need to have my refills in place. Especially before this more or less two week vacation that I've been on. So I've had plenty of medication to fulfill my regiment of medication." In sum, the modified TAM-based SMRA training content appeared to target training group participants' perceived usefulness.

**Research question 1.2.** Is there a difference in perceived ease of use between before and after the modified TAM-based SMRA training? RQ1.2 was to assess if there is a difference in perceived ease of use between before and after the modified TAM-based SMRA training. As mentioned previously, TAM proposes perceived ease of use as a determinant of intention to use an SMRA (the more people feel at ease using the app, the more likely they are to intend to use the app). Assessing the viability of the modified TAM-based SMRA training in targeting (or increasing the level of) perceived ease of use is therefore important to assess the viability of the training in increasing the level of intention to use the app.

Wilcoxon signed-rank test revealed that there was a significant difference in the level of perceived ease of use:  $z = -2.55, p < .05$ . Training group participants reported higher level of perceived ease of use immediately after the modified TAM-based SMRA training ( $Mdn = 7.00$ ) than before the training ( $Mdn = 5.67$ ).

Qualitative data appear to support this finding, revealing that training group participants found TAM-based SMRA training with step-by-step instructions on app use to be helpful in learning about the app. For example, Grace said, “I just think having somebody to show you how this, the app worked and how you load things onto the app, I think that it was just helpful to have somebody to be able to do that.” Michael expressed a similar opinion:

You took your time and you’re very patient on teaching me the app and walking me through the app. So, to me, you were excellent and in explaining and going through the app, and with me, having a brain injury, like I said, 20 plus years ago, sometimes it’s hard to get things into my brain. But you were very easy and very, you explained things well and how the app worked and how I needed.

In addition, non-training group participants indicated that the modified TAM-based SMRA training would be suitable for them in learning about the app. For example, Scarlett said, “older adults like teacher-lead, hands-on, repetitive steps. We don’t learn the same way the whippersnappers do.” Regarding the content of an SMRA training they would like to receive, Samuel said, “add a few more cues. Install a link to an alarm signal. Make it easier to add/delete/change med information,” and Morgan said, “finding the right meds and setting dosages.” In sum, the modified TAM-based SMRA training content appeared to target training group participants’ perceived ease of use.

**Research question 1.3.** Is there a difference in positive subjective norm between before and after the modified TAM-based SMRA training? RQ1.3 was to assess if there is a difference in positive subjective norm between before and after the modified TAM-based SMRA training. As mentioned previously, TAM posits positive subjective norm as a determinant of intention to use an SMRA (the more positive a user thinks family members or healthcare providers’ view on the app use would be, the more likely he or she is to intend to use the app). Assessing the viability of the modified TAM-based SMRA training in targeting (or increasing the level of) positive subjective norm is therefore important to assess the viability of the training in increasing the level of intention to use the app.

Wilcoxon signed-rank test revealed that there was no significant difference in the level of positive subjective norm between before and immediately after the modified TAM-based SMRA training ( $Mdn = 4.00$ ,  $Mdn = 4.57$ , respectively):  $z = -0.63$ ,  $p = .53$ .

Qualitative data appear to explain this finding. Qualitative data indicated that the modified TAM-based SMRA training content designed to target positive subjective norm

corresponded with training group participants' descriptions of positive subjective norm. Modified TAM-based SMRA training content included the introduction of the real-world utility of SMRA for family members in communicating medication information on the patients' app to healthcare providers on behalf of patient. One month after modified TAM-based SMRA training, Jayden (Chloe's husband) and Chloe (Jayden's wife) appeared to agree with this utility of SMRA in their positive recollections of using the app together.

They described using the Medisafe<sup>®</sup> app together as Medfriends and stated that Medfriend feature was critically helpful when Jayden went to the emergency room and Chloe needed to explain Jayden's medication information to healthcare providers. Jayden said, "I suffered what they called a GI which they also called for a layman's understanding, mini-stroke. So at that particular time I was totally unable to speak and, or move," and said, "of course they [healthcare providers] wanted to know what medications I was taking. [...] They found it [SMRA] very helpful in treating me. And they were surprised that I had it." Jayden also said, "Chloe bein' familiar with the app was able to open the app and give the medical, treatment folks vital information on the medicines that I was taking. And they thought that it was good." Chloe also said "so they were asking me about his medication, and so, I, because I was his Medfriend, I was able to see all of his medicine, medication. [...] I was very glad that we both had it."

However, qualitative data also revealed that the modified TAM-based SMRA training did not introduce the utility of the app in relieving family members from responsibility for supporting participants in medication adherence. For example, Olivia said, "if I did [take medications throughout the day], I think of course, my family

members would be glad to know that I was going to get reminded so they didn't have to remind me." In addition, Michael described his wife's positive perception of SMRA helping remind him to take medications, saying, "She thinks this is very good for her husband, that she doesn't have to keep reminding me when to take my pills and my medicine. So it's been awesome relieving her from a duty." In sum, the modified TAM-based SMRA training might better and significantly target positive subjective norm if the training also emphasized the real-world utility of SMRA in reducing need for family members to remind participants of medication taking.

**Research question 1.4.** Is there a difference in intention to use an SMRA between before and after the modified TAM-based SMRA training? RQ1.4 was to assess if there is a difference in intention to use an SMRA between before and after the modified TAM-based SMRA training. As mentioned previously, TAM posits intention to use an SMRA as the determinant of app use. Assessing the viability of the modified TAM-based SMRA training in increasing the level of intention to use the app is therefore important to assess the viability of the training in promoting app use.

Wilcoxon signed-rank test revealed that there was a significant difference in the level of intention to use an SMRA:  $z = -2.11, p < .05$ . Training group participants reported higher level of intention to use an SMRA immediately after the modified TAM-based SMRA training ( $Mdn = 6.50$ ) than before the training ( $Mdn = 5.67$ ).

**Research questions 1.5.** Is there a difference in medication adherence variables (self-reported medication adherence and medication adherence self-efficacy) between before and after the modified TAM-based SMRA training? RQ1.5 was to assess if there is a difference in self-reported medication adherence between before and after the

modified TAM-based SMRA training. In addition, RQ1.5 was to assess if there is a difference in medication adherence self-efficacy between before and after the modified TAM-based SMRA training. As mentioned previously, positive impacts of SMRA use on medication adherence have been reported. In addition, the modified TAM-based SMRA training that increases the level of intention to use the app through targeting perceived usefulness and perceived ease of use is likely to lead participants to adopt the use of the app and, thereby, support medication adherence using the app. Assessing the viability of the modified TAM-based SMRA training in increasing the levels of medication adherence variables is therefore important to assess the viability of the training as an intervention to promote app use and, thereby, support medication adherence.

Medication adherence was measured in multiple ways: a medication adherence scale assessing the degree to which participants took all medications over the past 7 days, a medication adherence item assessing how often participants have difficulty remembering to take medications, a medication refill item, and a medication adherence self-efficacy scale assessing the degree to which participants feel confident in medication adherence. None of these measures indicated statistically significant differences in medication adherence between before and immediately after the modified TAM-based SMRA training.

Wilcoxon signed-rank test revealed that there was no significant difference in the level of medication adherence scale between before and one month after the modified TAM-based SMRA training:  $z = -1.74, p = .08$ . In addition, there was no significant difference in the level of medication adherence item between before and one month after the modified TAM-based SMRA training:  $z = -1.73, p = .08$ . In addition, McNemar test

revealed that there was no significant difference in the proportion of “timely refill” participants between before (93%, 13/14) and one month after (86%, 12/14) the modified TAM-based SMRA training:  $p > .99$ . In addition, paired  $t$ -test revealed that there was no significant difference in the level of medication adherence self-efficacy between before and one month after the modified TAM-based SMRA training:  $t(9) = 0.60, p = .57$ .

In both the baseline and second follow-up survey, the level of medication adherence item (how often do you have trouble remembering to take all your medications?; Bartlett Ellis et al., 2018) was low for the training group participants ( $Mdn = 2.00$  for both baseline and second follow-up). On the other hand, training group participants’ responses to items such as “I missed or skipped at least one dose of my prescribed medication” on the medication adherence scale (Voils et al., 2012), indicated their suboptimal level of medication adherence (optimal level of medication adherence is “1.00” for medication adherence scale) for both baseline and second follow-up ( $Mdn = 1.50, Mdn = 3.00$ , respectively).

In other words, for the training group participants in this research, although their level of medication nonadherence is suboptimal, forgetting to take medications might not be a major barrier to taking medications as prescribed. For example, among the training group participants, there were participants who indicated having no difficulty remembering to take medications in a timely manner. Specifically, Edward said, “I only take the one medicine, so I don’t have a lot of variables involved,” and Olivia said, “I take two pills in the morning, and I take one once a week. And so I don’t need reminders throughout the day. [...] I’m taking these two medications so long, I just automatically take them every morning.” In addition, Susanna said, “since I take my medications in the

morning and have for so long, I'm pretty regimented," and Brianna said, "it [medication taking reminder] comes up every night at the time that we set it for. [...] I hear the shake shake [reminder sound]. And I will have already taken the meds."

Considering such findings, the modified TAM-based SMRA training—an intervention designed to help individuals to remember to take medications using app features such as the medication taking reminder—might not be an intervention that ensures improvement in medication adherence for training group participants who have relatively simple medication regimens.

**Assessment of potential impact of training format.** In addition, within the training group, I assessed if there were significant differences in baseline, first follow-up, and second follow-up data between participants who received modified TAM-based SMRA training individually and as a group (two to four participants).

Independent samples *t*-tests (for variables that Shapiro-Wilk's *W* tests revealed were normally distributed) revealed that there was no significant difference in age between participants who received modified TAM-based SMRA training individually and as a group. Independent samples *t*-test, however, revealed that there was a significant difference in the level of medication adherence self-efficacy between participants who received modified TAM-based SMRA training individually and as a group at the baseline period. Levene's test for equality of variances was not significant ( $F = 4.36, p = .06$ ), so equality of variances was assumed:  $t(10) = -2.80, p < .05$ . Participants who received modified TAM-based SMRA training individually ( $M = 3.69, SD = 0.15$ ) reported significantly higher level of medication adherence self-efficacy than those that received group training at the baseline period ( $M = 2.80, SD = 0.53$ ).



Mann-Whitney  $U$  tests revealed that there were no significant differences in education, income, number of prescribed medication, number of other medication (e.g., vitamins, supplements, etc.), Medisafe<sup>®</sup> app use self-efficacy, perceived usefulness (both baseline and first follow-up), perceived ease of use (both baseline and first follow-up), positive subjective norm (both baseline and first follow-up), intention to use an SMRA (both baseline and first follow-up), app use (self-report), medication adherence scale measured during the second follow-up period, medication adherence item measured during the second follow-up period, and perceived impact of an SMRA training between participants who received modified TAM-based SMRA training individually and as a group.

Mann-Whitney  $U$  tests, however, revealed that there was a significant difference in the level of medication adherence scale between participants who received modified TAM-based SMRA training individually and as a group at the baseline period:  $U = 6.00$ ,  $z = -2.14$ ,  $p < .05$ . Participants who received modified TAM-based SMRA training individually ( $Mdn = 1.00$ ) reported significantly higher level of medication adherence than those that received group training ( $Mdn = 2.00$ ). In addition, there was a significant difference in the level of medication adherence item between participants who received modified TAM-based SMRA training individually and as a group at the baseline period:  $U = 6.00$ ,  $z = -2.23$ ,  $p < .05$ . Participants who received modified TAM-based SMRA training individually ( $Mdn = 1.25$ ) reported significantly higher level of medication adherence than those that received group training ( $Mdn = 3.00$ ).

Chi-square tests revealed that there were no significant differences in gender, ethnicity, race, chronic condition type, phone type, the proportion of those with health-

related smartphone use experience, and the proportion of “timely refill” participants (for both baseline and second follow-up) between participants who received modified TAM-based SMRA training individually and as a group. Such findings support the findings on the utility of modified TAM-based SMRA training in targeting TAM variables, irrespective of individual or group training format.

In sum, the modified TAM-based SMRA training was found to be viable in significantly increasing the levels of perceived usefulness, perceived ease of use, and intention to use the app for training group participants. However, the modified TAM-based SMRA training was not viable in significantly increasing the levels of positive subjective norm and medication adherence variables.

Table 3

*Differences in Outcome Variables Between Before and After the Modified TAM-Based SMRA Training*

Variables	Baseline			Follow-up			
	IQR <sup>a</sup>	<i>M</i> ( <i>SD</i> )	<i>Mdn</i>	IQR	<i>M</i> ( <i>SD</i> )	<i>Mdn</i>	<i>p</i>
Intention to use an SMRA	5.00-7.00	5.71 (1.05)	5.67	6.00-7.00	6.38 (0.70)	6.50	.04 <sup>a</sup>
Perceived usefulness	4.67-7.00	5.42 (1.57)	5.67	6.17-7.00	6.70 (0.46)	7.00	.003 <sup>a</sup>
Perceived ease of use	4.88-7.00	5.57 (1.64)	5.67	6.00-7.00	6.60 (0.65)	7.00	.01 <sup>a</sup>
Positive subjective norm	3.57-4.71	4.30 (0.94)	4.00	4.00-4.86	4.43 (0.71)	4.57	.53 <sup>a</sup>
Medication adherence scale	1.50-4.00	2.43 (1.39)	1.50	1.00-3.63	2.86 (1.35)	3.00	.08 <sup>a</sup>
Medication adherence item	1.00-3.00	1.87 (0.99)	2.00	1.00-3.00	2.07 (0.88)	2.00	.08 <sup>a</sup>
Medication refill item	—	—	—	—	—	—	>.99 <sup>b</sup>
Adherence self-efficacy	2.48-3.65	3.02 (0.61)	3.11	2.63-3.11	2.91 (0.60)	2.85	.57 <sup>c</sup>

*Note.* IQR = interquartile range.

<sup>a</sup>*p* values calculated using Wilcoxon signed-rank tests. <sup>b</sup>*p* value calculated using McNemar test. <sup>c</sup>*p* value calculated using paired *t*-test.

## **Aim 2. Estimation of Effect Sizes for Modified TAM-Based SMRA Training**

The second aim of this study was to estimate effect sizes for the modified TAM-based training on outcome variables to inform power analyses for a larger efficacy study. Research questions 2.1 to 2.6, comparing the training and non-training groups' ratings of perceived usefulness, perceived ease of use, positive subjective norm, intention to use the SMRA, app use, and medication adherence variables, were used to estimate effect sizes for the modified TAM-based training.

For perceived usefulness, perceived ease of use, positive subjective norm, intention to use an SMRA, the medication adherence scale, the medication adherence item, medication adherence self-efficacy, Medisafe<sup>®</sup> app use self-efficacy, and SMRA use (self-report), I first conducted Shapiro-Wilk's  $W$  tests with pairwise deletion (for all participant data) to assess if they met the assumption for normal distribution. Results revealed that all but positive subjective norm for the first and second survey ( $p = .16$  and  $p = .88$ , respectively) and medication adherence self-efficacy for the first and third survey ( $p = .07$  and  $p = .14$ , respectively) were not normally distributed. For RQ2.1-2.2 and 2.4-2.5, I therefore conducted Wilcoxon signed-rank tests for non-normally distributed variable data. For RQ2.5, I additionally conducted a chi-square test for the medication refill item data for which I classified participants as either "timely refill" or "late refill" participants. For RQ2.3 and 2.5, I conducted independent samples  $t$ -tests for normally distributed positive subjective norm data and medication adherence self-efficacy data, respectively. For RQ2.6, I conducted a Wilcoxon signed-rank test for non-normally distributed SMRA use (self-report) data and chi-square test for SMRA use data (i.e., participants' one-month Medisafe<sup>®</sup> app usage data) for which I classified participants as

either “one month” user (more active user than) or “less than a month” user. The results of these tests are presented in Table 4.

Before I started answering RQ2.1-2.6, I assessed if there were significant differences in eHealth technology use (Medisafe<sup>®</sup> app use self-efficacy and health-related smartphone use experience), TAM, and medication adherence variables between training group and non-training group at baseline (before modified TAM-based SMRA training and self-app navigation). As mentioned previously, such an assessment is important to check if there might be a selection effect (e.g., potential impacts that between-group difference in Medisafe<sup>®</sup> app use self-efficacy at baseline might have on perceived ease of use) that would make precise estimation of effect sizes for the modified TAM-based SMRA training difficult.

Mann-Whitney  $U$  tests revealed that there were no significant differences in the levels of perceived usefulness ( $U = 66.00, z = -0.87, p = .41$ ), perceived ease of use ( $U = 78.00, z = -0.31, p = .78$ ), intention to use an SMRA ( $U = 76.00, z = -1.02, p = .34$ ), medication adherence scale ( $U = 76.00, z = -1.02, p = .34$ ), medication adherence item ( $U = 96.50, z = -0.05, p = .96$ ), and Medisafe<sup>®</sup> app use self-efficacy ( $U = 92.00, z = -0.26, p = .82$ ) between the training group and the non-training group at baseline. Regarding positive subjective norm, independent samples  $t$ -test revealed that Levene’s test for equality of variances was not significant ( $F = 0.16, p = .70$ ), so equality of variances was assumed:  $t(25) = 0.56, p = .58$ . There was no significant difference in the level of positive subjective norm at baseline between the training group and the non-training group. Regarding medication adherence self-efficacy, independent samples  $t$ -test revealed that Levene’s test for equality of variances was not significant ( $F = 0.24, p =$

.63), so equality of variances was assumed:  $t(21) = -1.00, p = .33$ . There was no significant difference in the level of medication adherence self-efficacy at baseline between the training group and the non-training group. In addition, a chi-square test revealed that there was no significant difference in the proportion of those with health-related smartphone use experience between the training group and the non-training group:  $\chi^2(1, N = 28) = 0.55, p = .46$ . Also, there was no significant difference in the proportion of “timely refill” participants between the training group and the non-training group:  $\chi^2(1, N = 25) = 0.82, p = .37$ . These findings indicate that precise estimation of effect sizes for the modified TAM-based SMRA training is possible, given that the change in outcome variables is likely to be attributable to whether the participants received TAM-based SMRA training or self-navigated app, rather than to any selection effects.

**Research question 2.1.** Is there a difference in perceived usefulness between those with and without TAM-based SMRA training? RQ2.1 was to assess if there is a difference in perceived usefulness between the training group and the non-training group. A Mann-Whitney  $U$  test revealed that there was a significant difference in the level of perceived usefulness between the training group and the non-training group at the first follow-up period (immediately after TAM-based SMRA training and self-app navigation):  $U = 27.00, z = -3.00, p < .01$ . The training group ( $Mdn = 7.00$ ) reported significantly higher level of perceived usefulness than the non-training group ( $Mdn = 5.50$ ).

**Research question 2.2.** Is there a difference in perceived ease of use between those with and without TAM-based SMRA training? RQ2.2 was to assess if there is a

difference in perceived ease of use between the training group and the non-training group. A Mann-Whitney  $U$  test revealed that there was a significant difference in the level of perceived ease of use between the training group and the non-training group at the first follow-up period:  $U = 38.50, z = -2.38, p < .05$ . The training group ( $Mdn = 7.00$ ) reported significantly higher level of perceived ease of use than non-training group ( $Mdn = 5.50$ ).

**Research question 2.3.** Is there a difference in positive subjective norm between those with and without TAM-based SMRA training? RQ2.3 was to assess if there is a difference in positive subjective norm between the training group and the non-training group. An independent samples  $t$ -test revealed that Levene's test for equality of variances was not significant ( $F = 1.78, p = .20$ ), so equality of variances was assumed:  $t(24) = 2.15, p < .05$ . The training group ( $M = 4.43, SD = 0.71$ ) reported significantly higher level of positive subjective norm than the non-training group ( $M = 3.57, SD = 1.31$ ) at the first follow-up period.

**Research question 2.4.** Is there a difference in intention to use an SMRA between those with and without TAM-based SMRA training? RQ2.4 was to assess if there is a difference in intention to use an SMRA between the training group and the non-training group. A Mann-Whitney  $U$  test revealed that there was a significant difference in the level of intention to use an SMRA between the training group and the non-training group at the first follow-up period:  $U = 34.00, z = -2.19, p < .05$ . The training group ( $Mdn = 6.50$ ) reported significantly higher level of intention to use an SMRA than the non-training group ( $Mdn = 5.50$ ).

**Research question 2.5.** Is there a difference in medication adherence variables (self-reported medication adherence and medication adherence self-efficacy) between those with and without TAM-based SMRA training? RQ2.5 was to assess if there is a difference in medication adherence variables between the training group and the non-training group. A Mann-Whitney  $U$  test revealed that there was no significant difference in the level of medication adherence scale between the training group and the non-training group at the second follow-up period (one month after TAM-based SMRA training and self-app navigation):  $U = 50.50, z = -1.51, p = .15$ . In addition, there was no significant difference in the level of medication adherence item between the training group and the non-training group at the second follow-up period:  $U = 66.50, z = -0.88, p = .41$ . In addition, a chi-square test revealed that there was no significant difference in the proportion of “timely refill” participants between the training group (86%, 12/14) and the non-training group (100%, 9/9) at the second follow-up period:  $\chi^2(1, N = 23) = 1.41, p = .24$ .

Regarding medication adherence self-efficacy, an independent samples  $t$ -test revealed that Levene’s test for equality of variances was not significant ( $F = 0.10, p = .78$ ), so equality of variances was assumed:  $t(20) = -2.53, p < .05$ . Non-training group participants ( $M = 3.51, SD = 0.48$ ) reported significantly higher level of medication adherence self-efficacy than training group participants ( $M = 2.91, SD = 0.60$ ) at the second follow-up period. Such findings might be attributable to the fact that the non-training group reported taking more prescribed medications and other medications such as vitamins and supplements ( $Mdn = 4.50, Mdn = 2.00$ , respectively) than the training group ( $Mdn = 3.00, Mdn = 1.00$ , respectively). Because they are taking more

medications, non-training group participants might need to make more of an effort to remember to take and refill medications than training group participants. Learning about the availability of SMRA might have helped non-training group participants increase their confidence in remembering to take and refill medications more than training group participants.

**Research question 2.6.** Is there a difference in SMRA use between those with and without TAM-based SMRA training? RQ2.6 was to assess if there is a difference in SMRA use between the training group and the non-training group. A Mann-Whitney  $U$  test revealed that there was no significant difference in the level of SMRA use (self-report) between the training group and the non-training group at the second follow-up period:  $U = 68.00, z = -0.81, p = .47$ . In addition, a chi-square test revealed that there is no significant difference in the number of “one month” users between the training group and the non-training group:  $\chi^2(1, N = 12) = 1.03, p = .31$ . The proportion of “one month” users was higher in the training group (86%, 6/7) than in the non-training group (60%, 3/5).

When focusing on the Android phone user data only (as Android phone user data was available in both the training group and the non-training group data set), all Android phone users in the training group (100%, 4/4) were found to be “one month” users, whereas three of five Android phone users in the non-training group (60%, 3/5) were found to be “one month” users, although a chi-square test revealed that there was no significant difference in the number of “one month” user between the training group and the non-training group:  $\chi^2(1, N = 9) = 2.06, p = .15$ . As mentioned previously, training group participants’ level of perceived impact of an SMRA training was measured to



assess whether and to what extent they think the training contributed to their app use. The majority of training group participants (87%, 13/15) agreed that modified TAM-based SMRA training helped them think about more and started using the app, reporting perceived impact of an SMRA training scale scores 5 or higher.

Qualitative data indicated that the modified TAM-based SMRA training was helpful in promoting app use through targeting TAM variables. Training group participants described their current app use in terms of reasons associated with TAM variables. For example, Kevin said he keeps using an SMRA because of its user-friendliness (perceived ease of use): “I would say using the two [medication taking and refill reminder features] that I have worked with, it’s been very, very user friendly and so I haven’t had any problems with any of the aspects of it so far.” In addition, Chloe described using an SMRA because it is helpful in taking medications and keeping track of doses (perceived usefulness), saying, “it’s very helpful to, in checking the app, and taking the medications, but it’s also really helpful in, to be able to look at a glance and see what medications I’m on, and what the dosages are.” Jayden described using an SMRA because others might find it convenient to check his medication information when needed (positive subjective norm), saying:

[When asked about why he is using an SMRA] it’s easy for someone to access in case I can’t get to my note [with prescriptions] where I may know where it’s kept, but they don’t know where it’s kept. They can see icon from the app, open the app, and get that information.

In sum, the modified TAM-based SMRA training appeared to target TAM variables and, thereby, promote app use. These findings indicate the utility of modified TAM-based SMRA training as an intervention that promisingly promotes app use, guided by TAM.

Table 4

*Differences in Outcome Variables Between Training Group and Non-Training Group*

Variables	Training Group			Non-Training Group		
	IQR	<i>M</i> ( <i>SD</i> )	<i>Mdn</i>	<i>M</i> ( <i>SD</i> )	<i>Mdn</i>	<i>p</i>
Intention to use an SMRA	5.00-7.00	6.38 (0.70)	6.50	5.03 (1.75)	5.00	.04 <sup>a</sup>
Perceived usefulness	5.75-7.00	6.70 (0.46)	7.00	5.58 (1.21)	5.50	.003 <sup>a</sup>
Perceived ease of use	5.50-7.00	6.60 (0.65)	7.00	5.62 (1.28)	5.50	.02 <sup>a</sup>
Positive subjective norm	3.39-4.64	4.43 (0.71)	4.57	3.57 (1.31)	3.71	.04 <sup>b</sup>
Medication adherence scale	1.00-3.50	2.86 (1.35)	3.00	1.91 (1.22)	1.00	.15 <sup>a</sup>
Medication adherence item	1.00-3.00	2.07 (0.88)	2.00	1.82 (1.08)	1.00	.41 <sup>a</sup>
Medication refill item	—	—	—	—	—	.24 <sup>c</sup>
Adherence self-efficacy	2.75-3.77	2.91 (0.60)	2.85	3.51 (0.48)	3.73	.02 <sup>b</sup>
SMRA use (self-report)	4.00-6.00	4.40 (1.84)	4.00	5.00 (1.55)	6.00	.47 <sup>a</sup>
SMRA use (app data)	—	—	—	—	—	.31 <sup>c</sup>

*Note.* IQR = interquartile range.

<sup>a</sup>*p* values calculated using Mann-Whitney *U* tests. <sup>b</sup>*p* values calculated using independent samples *t*-tests. <sup>c</sup>*p* values calculated using chi-square test.

**Effect sizes.** Considering the utility of the modified TAM-based SMRA training in increasing the level of perceived usefulness, perceived ease of use, positive subjective norm, and intention to use the app, I estimated effect sizes for the modified TAM-based SMRA training versus self-app navigation on these variables. For effect size for the modified TAM-based SMRA training on positive subjective norm (analyzed with independent samples *t*-test), I calculated the effect size using the formula that uses *t* value: Cohen's  $d = t\sqrt{n_A+n_B/n_A n_B}$  (Cohen, 1988), an alternative to the formula: Cohen's  $d = M_1 - M_2 / \text{pooled } SD$  (Cohen, 1988; Ellis, 2010; Rosenthal, 1994). Effect sizes expressed as *d* over .80 are deemed large (Cohen, 1988; Grove et al., 2013). The effect size on positive subjective norm was large:  $0.85 = 2.15\sqrt{26/165}$ .

For effect sizes for the modified TAM-based SMRA training on perceived usefulness, perceived ease of use, and intention to use an SMRA (analyzed with Mann-

Whitney  $U$  tests), I calculated effect sizes using the formula:  $r = \sqrt{z^2/N}$  (Rosenthal, 1991). Effect sizes expressed as  $r$  between .30 and .50 are deemed medium, and effect sizes over .50 are deemed large (Cohen, 1988; Grove et al., 2013). The effect size on perceived usefulness was large:  $0.59 = \sqrt{(-2.998)^2/26}$ ; the effect size on perceived ease of use was medium:  $0.47 = \sqrt{(-2.380)^2/26}$ ; and the effect size on intention to use an SMRA was medium:  $0.45 = \sqrt{(-2.188)^2/24}$ .

Considering these effect sizes, at least 52 participants (26 per group) will be required for a larger efficacy study with a two-tailed alpha level of .05 and power of 80% (see Ellis, 2010, p. 62 for power table). Furthermore, considering a sample size that is enough for the estimation of test-retest reliability of variable scales (35-40 per group; Hertzog, 2008), the recruitment of 70-80 participants would be desirable.

### **Aim 3. Understanding of the Ways to Improve Modified TAM-Based SMRA**

#### **Training**

The third aim of this dissertation was to gain insight into how to improve the delivery of the modified TAM-based SMRA training in preparation for a larger efficacy study. Research question 3 was used to meet this aim.

**Research question 3.** What perceptions do participants describe in relation to SMRA training delivery? Through telephone interviews (training group) and open-ended questions (non-training group), participants described their thoughts and suggestions regarding SMRA training delivery, including format (face-to-face versus online training format and small group versus individual training format), length, and material.

*Separate SMRA training for iPhone and Android phone users.* As mentioned previously, in the PPT slides, I included step-by-step instructions (i.e., instructions on

how to set up app accounts and how to use app features for the training group and instructions on how to set up app accounts for non-training group) for both iPhone users and Android phone users when appropriate. This was done in order to help iPhone users and Android phone users follow only instructions applicable to their own phones (Park et al., 2017).

Participants in the groups including both iPhone and Android users indicated that, even with separate step-by-step instructions, introducing SMRA to different types of users at the same time could result in confusion in learning about the app. For example, William said, “they’re [iPhone and Android phone Medisafe® app] different enough that it’s, can be a little confusing.” Emily agreed: “Some of us had iPhones and others had Android. And that was a little bit of an issue. [...] having training with the same technology would be helpful.” Scarlett also indicated her preference for learning about SMRA within the group of same phone users, saying, “yes, slow, clear instructions would be helpful. And get those Android folks out of the room, we Apple people want our own training.” William also indicated that training a group of same phone users could be more time-efficient than training a group of different phone users, saying, “you were trying to cover both platforms. I think if you had been able to just focus on either iPhones or Android, [...] I don’t know if two hours would’ve been needed.” In sum, qualitative results indicated that providing modified TAM-based SMRA training to groups of same phone users could help them learn about the app in a time-efficient manner with less confusion.

***Face-to-face training and live online training opportunities.*** For this research, I met all training group participants in person and provided modified TAM-based SMRA

training. Participants described face-to-face training as helpful to older adults who are not tech-savvy in learning about SMRA. For example, Michael said, “being maybe not as savvy as technical experts as I am, [...] I think I wouldn’t got as much as much training and hands on experience if it was not the face to face session.” Edward agreed: “For somebody my age, having somebody show me how to do it, you know, ‘press this button, do this button,’ is much easier for me to learn something like this.” In addition, participants described face-to-face training as helpful because the trainer could check participants’ understanding of instructions on SMRA use. For example, Olivia said, “I think the face to face is better. [...] yourself, as a trainer, can get a feel for somebody better if it’s face to face, whether they’re going to understand what you’re telling them.” Similarly, Jacob said, “I think face to face is always better. [...] trainer gets to see the person’s facial expressions and know whether they’re actually understanding the instructions.”

Throughout the almost two-month period, I was able to meet 15 training group participants and provide them with modified TAM-based SMRA training. As mentioned previously, estimation of effect sizes for modified TAM-based SMRA training indicated 52 participants (26 per group) as a required sample size for a larger efficacy study. Considering this, it is important to address how to deliver modified TAM-based SMRA training to larger number of participants in a time-efficient manner.

Regarding this concern, participants suggested conducting modified TAM-based SMRA training at places where participants can naturally meet as a group (as I conducted non-training group meeting at church where participants are parishioners). For example, Edward said:

You could do a small group like that in a location where people just naturally gather. I think that would be a good way to reach out to multiple people without a lot of effort on your part or a lot of inconvenience on their part.

Furthermore, participants suggested a live online session as a useful way to complement face-to-face training. For example, William said, “if you were to develop an online program, you’d be able to reach more people faster.” More specifically, Participants described their suggestions regarding a live online training. For example, Chloe suggested that “maybe the online training [...] could be a situation where they can talk to a live, do a live chat or something. So they can have that almost face to face feel.” Jayden agreed: “I think you could translate into a real-world, um, online situation easily. [...] the only thing that I could say [...] would just be to make it as flow as smoothly as the live version.” Emily described the utility of web-based audiovisual communication tools, such as Skype or Facetime, as a live online training channel, saying, “I could see that online training would work, especially if you could, maybe do like Skype, or FaceTime, or some way, you know, to see each other in case you needed to share screens or something like that.” In addition, William indicated that a live online training would be helpful if a trainer could answer participants’ SMRA-related inquiries in real time, saying “you need to have some kind of expertise available to address specific questions. [...] help desk, or something like that.” In sum, qualitative results indicated that making live online training opportunities available, in addition to face-to-face sessions, could help reach out to and train the number of participants needed for a larger efficacy study.

***Small group training with peer helper.*** As mentioned previously, I provided modified TAM-based SMRA training to training group participants either individually or as a small group at each of their convenience. To gain insight into the optimal training

format (individual training versus small group training) for a larger efficacy study, I asked participants about their perceptions regarding training format.

Participants described small group training as helpful in terms of the advantages that can come from working as a group. For example, participants described the utility of small group training in sharing app-related questions and opinions that they might not think of in an individual training setting. For example, Kevin said, “they had a question that I maybe didn’t think of, and they were able to present that question [...] when they brought some different things up, it was very beneficial for me too as well.” Seth agreed: “There’s questions that come out that people don’t always think of, so sometimes you hear additional opinions.” In addition, participants described small group training as a time-efficient way to train multiple participants. For example, Edward said, “I think small group would be just fine. [...] And certainly more efficient.” Similarly, Grace said, “it would save you from having to do it one on one, and I think that you could get as much out of it if you had a small group, I think it would save you time.”

In contrast, other participants indicated that individual training might be a better training format if participants differed significantly in their level of tech-savviness and required varying amounts of the trainer’s attention. For example, Emily described her frustration she experienced in a small group training setting, saying, “my more experienced people in the group were adding medications, and they were already adding, you know, [reminder] sounds, and all that kind of stuff, and I had no idea how to do any of that.” Emily attributed this frustration to the fact that the trainer had to divide attention to multiple participants, saying, “some of us had to wait while other people were catching up, and thing like that. That’s why I kind of think that one on one would be a better way

to do it than in a group.” Susanna also saw this limitation of one trainer-led group training, saying, “some people might be frustrated that they have to wait to get the training, so I can see why one-on-one [might be better], that way you know, you’re giving them your undivided attention.”

Regarding this concern, participants indicated the utility of a peer helper (with high level of tech-savviness) in assisting the participants who need additional help. For example, Brianna said, “sometimes, other people can help you see what’s being done or said from their perspective, you know, easier. [...] especially if there’s someone who [is] not particularly familiar with the computer.” Seth noted, “you have the benefit of when you do it in a group setting, that there are others that are, pick up on it quicker, and then they may be able to explain that to other people.” During one of training group meetings, one participant helped another participant download an SMRA to a smartphone while I was dividing my attention among multiple participants. This peer helper was truly helpful for me in making sure that all participants were on the same page and in making progress in the modified TAM-based SMRA training as planned.

Indeed, helping 14 non-training group participants set up app accounts as a group was definitely challenging, and working with a couple of peer helpers (e.g., those who already completed setting up app accounts) might be instrumental in overcoming this challenge in single trainer-led group training. In sum, qualitative results indicated small group training with peer helper could be a useful way to train participants across different levels of tech-savviness learn about an SMRA together for a larger efficacy study.

***Working with family members and healthcare providers.*** For this dissertation, I provided modified TAM-based SMRA training to only those taking medication for



chronic condition management. These participants suggested the potential utility of conducting modified TAM-based SMRA training with family members and healthcare providers in helping participants learn about and utilize the app. For example, Edward suggested training participants and family members to use an SMRA as a potentially useful way to help the family, as a support network, work together in encouraging participants in medication adherence using the app, saying:

People that are going to be involved in [using] the Medisafe [app with participant] and, you know, a daughter or a son or something like that, that's gonna be getting that Medisafe affiliation from the main person [...] bring them in and have them sit through the whole presentation as well. [...] who like I said, would've been my father-in-law and my mother-in-law, like I mentioned, maybe have myself and my daughter go, so we could understand what it was and how it feel, functions.

Seth suggested working with healthcare professionals as co-trainers as a potentially useful way to conduct the modified TAM-based SMRA training in a healthcare facility setting. Seth said, “reach out to medical practitioners, [...] nursing homes, and things of that nature, maybe that would be a good place to introduce the app and teach individuals in groups on how to use it.” Seth also said, “let’s imagine we have, like, healthcare providers, or something like that as a partner. [...] for those people who struggle with technology, it might be better to have somebody hands-on there.” In sum, qualitative results indicated the potential utility of inviting participants’ family members as co-trainees to better support participants in medication adherence using an SMRA. Further, it was indicated that working with healthcare providers, as co-trainers, could be helpful in delivering modified TAM-based SMRA training to participants in a healthcare facility setting for a larger efficacy study.

***Tailoring training length to participant preference.*** For this research, training group participants differed in the length of modified TAM-based SMRA training they received (up to two hours) depending on each of their time availability. To gain insight into the optimal length of the modified TAM-based SMRA training for a larger efficacy study, I asked participants about their perceptions of training length (whether it was too long or short). Rather than reaching a consensus on the specific training length, the participants indicated the need for tailoring training length to participant preference based on time availability or tech-savviness. For example, Kevin and Seth, who received the training for up to one hour said, “it was a little bit longer [...] this day and age, everybody wants it [to] be shorter and faster on anything you do. So, that part of it, you know, we like to have less time period” and “it is a bit long, I don’t know, if there’s a way to cut it down, smaller,” respectively. On the other hand, Michael described that two hours was a sufficient training length for him to learn about SMRA, saying, “I think the two hours was just about the right length of time to learn and to work with the app and for you to explain, you know, the app.” In sum, qualitative results indicated the need to consider participant preference in planning training length for a larger efficacy study.

***Training material to master SMRA features.*** For this dissertation, I provided the training group with one-time modified TAM-based SMRA training. After the training, participants indicated that one-time training is not enough for them to master SMRA features. Jayden suggested this, saying, “For someone that is not as tech savvy, [...] if they have questions that pop up and they were like, ‘man, I wish I had somebody to ask,’ there may not be a live person they can call to.” After the training, I actually helped some of participants use SMRA features they had not yet mastered. For example, during the

telephone interviews, Avery said, “I ended up needing a little bit more understanding in order to be able to change the time that the alarm would go off,” and Chloe said, “I have two vitamins that I take every third day. [...] trying to change them [medication taking reminders] to tomorrow, or to try to change to a different day was pretty problematic.” After the telephone interviews, I provided these participants with additional instructions on how to reschedule medication taking reminders.

In addressing the need for additional training, participants indicated the utility of SMRA training materials, such as an app training video or handout, in helping participants master app features at their own pace and through repetitive practice. For example, Susanna indicated the utility of an online training video in helping practice SMRA features without feeling pressure to follow the pace of instructions in a face-to-face training setting, saying, “I can see the benefit of having an online function because they could rewind and go back and do it at their own pace as well.” In addition, participants pointed to useful content that could be included in SMRA training video materials. Emily suggested providing an overview of SMRA training, saying, “there could be like a short, a very, very short video explaining what it is and what it does as sort of a precursor to the training. [...] hitting the highlights of what you’ll learn in the training session.” Seth suggested providing role-playing instructions on app use that viewers could follow, saying, “informative video might be a good way [...] where you have role play acting, for example, when you’re forming, maybe a small group of people where it’s videoed, people could follow along.” To make sure if participants mastered instructions on SMRA use, Susanna and Emily suggested including app-related tasks and frequently asked questions, saying, “giving them a task to do on the app and then maybe

answering a question or something so you know that they had comprehension of what they were doing” and “there could be training on a video that you could access, or may[be] like a frequently asked questions, something like that,” respectively.

In addition, participants indicated the utility of SMRA training handout as a post-training tool for mastering app features. For example, Brianna said, “you could have printed instruction where it [is] actually done in a 1 2 3 or ABC method so that people can follow that until they get it in their minds.” In addition, Avery suggested providing instructions on not only how to use SMRA features but also how to download the app to smartphone, saying, “if we had a printout that showed us how to do things, that might be helpful. [...] you might even for somebody else, you might need to describe the download process.” This dissertation revealed the viability of the modified TAM-based SMRA training content in targeting TAM variables. In this regard, creating and providing a modified TAM-based SMRA training video and handout for participants could help target TAM variables and encourage participants to master app features after the training for a larger efficacy study.

In conclusion, the modified TAM-based SMRA training was viable in increasing the levels of perceived usefulness, perceived ease of use, positive subjective norm, intention to use the app, and app use (i.e., app data indicating 86% of training group participants and 60% of non-training group participants were one month app users). However, the modified TAM-based SMRA training was not viable in increasing the levels of medication adherence variables. Furthermore, participants reported their perceptions and suggestions regarding SMRA training design that could be instituted in the development of a larger efficacy study.

## CHAPTER FIVE

### DISCUSSION

This dissertation was designed to help middle-aged to older adults with chronic conditions—a group at risk for medication nonadherence and its negative health-related outcomes—to better understand and utilize an SMRA to support medication adherence. To ascertain the utility of the modified TAM-based SMRA training as an intervention to promote app use, the first aim of this dissertation was to assess the viability of the training in increasing the level of TAM variables (i.e., perceived usefulness of the app in medication adherence, perceived ease of app use, and positive subjective norm regarding app use) and intention to use the app. Meeting this aim is important to ascertain whether the modified TAM-based SMRA training is helpful in meeting its goals. As mentioned previously, I first asked training group participants to explore any SMRA features briefly and to report their levels of TAM variables, intention to use an SMRA, and medication adherence variables including medication adherence self-efficacy, a medication adherence scale, a medication adherence item, and medication refill item variables (baseline). Next, I provided training group participants with modified TAM-based SMRA training and asked them to report their levels of TAM variables and intention to use an SMRA immediately after the training (first follow-up). I then assessed whether training group participants reported higher levels of TAM variables and intention to use an SMRA at first follow-up than at the baseline in order to assess the viability of the modified TAM-based SMRA training in targeting TAM variables.

The second aim of this dissertation was to estimate effect sizes for modified TAM-based SMRA training (for the training group) versus self-app navigation (for the

non-training group) on TAM variables, intention to use the app, app use, and medication adherence variables. Meeting this aim is important to ascertain the degree to which the modified TAM-based SMRA training is helpful in meeting its goals. As mentioned previously, I also asked non-training group participants to explore any SMRA features briefly and to report their levels of TAM variables, intention to use an SMRA, and medication adherence variables (baseline). Next, I asked non-training group participants to self-navigate app features for a longer time and to report their levels of TAM variables and intention to use an SMRA immediately (2-13 days) after self-app navigation (first follow-up). In addition, I asked both training group participants and non-training group participants to report their levels of SMRA use and medication adherence variables one month after the modified TAM-based SMRA training and self-app navigation, respectively (second follow-up). I then assessed whether training group participants reported higher levels of TAM variables and intention to use an SMRA at the first follow-up and higher levels of app use and medication adherence variables at the second follow-up period than non-training group participants.

The third aim of this dissertation was to obtain participants' opinions and suggestions regarding SMRA training delivery. Meeting this aim is important to ascertain how to improve the delivery of the modified TAM-based SMRA training for a larger efficacy study. I conducted telephone interviews with training group participants to obtain their suggestions regarding training delivery components, such as training format, length, location, and material. For the non-training group, I asked participants to respond to open-ended questions (as part of the second survey at the first follow-up period) to obtain their suggestions regarding training delivery components.

In this discussion chapter, I first discuss the key conclusions of this dissertation. I then describe implications as well as limitations and future directions. Lastly, I discuss the strengths of this dissertation.

### **Key Conclusions**

Findings from this dissertation indicate the utility of the modified TAM-based SMRA training as an intervention to promote app use for middle-aged to older adults with chronic conditions, guided by TAM. Results for the first aim revealed that the modified TAM-based SMRA training was viable in targeting perceived usefulness, perceived ease of use, and intention to use the app. Furthermore, the modified TAM-based SMRA training was found to be more helpful in promoting app use than self-app navigation. Results for the second aim revealed that the levels of perceived usefulness, perceived ease of use, positive subjective norm, and intention to use an SMRA were higher in the training group than in the non-training group. In addition, the proportion of active app users (those who continued app use for a month after group activity) was higher in the training group than in the non-training group. To establish internal validity (i.e., the causal relationship between the training and its outcomes), the utility of the modified TAM-based SMRA training should be assessed through a larger efficacy study with a sample size of at least 52 participants (estimated based on effect sizes for the training on TAM variables and intention to use the app).

### **Implications**

There are a number of implications of this dissertation. I will first discuss theoretical implication and then implication for SMRA training delivery and practical implications.

**Theoretical implication.** As reviewed previously, TAM has been utilized to examine factors influencing the adoption of smartphone healthcare app use, such as intention to use a technology and its determinants (i.e., TAM variables) including perceived usefulness, perceived ease of use, and positive subjective norm (Beldad & Hegner, 2018; Cho, Quinlan et al., 2014; Dou et al., 2017; Wang et al., 2014). The findings from this dissertation confirm findings from existing TAM literature, including the pilot study (Park et al., 2017), indicating a potential link between TAM variables and SMRA use (qualitative data supplements quantitative results). In other words, middle-aged to older adults are likely to be willing to and actively use an SMRA when they think the app is usable (perceived ease of use) and useful to them as well as their family members in supporting medication adherence (perceived usefulness and positive subjective norm).

Furthermore, following the pilot study (Park et al., 2017), the findings from the dissertation extend existing TAM literature by indicating the utility of TAM as a framework not only for understanding the determinants of SMRA use but for informing the design of intervention that would promote app use. As reviewed previously, existing studies on SMRA use have shown the utility of app training in promoting app use for middle-aged to older adults (Grindrod et al., 2014; Santo et al., 2019). In addressing how to promote SMRA use, however, there has been the gap between existing TAM and SMRA training literature. Specifically, TAM has not been utilized to inform the design of SMRA training, despite the potential utility of doing so in ensuring the adoption of app use (through targeting TAM variables). In other words, middle-aged to older adults are likely to be willing to and actively use an SMRA when the app training helps them think



the app is usable and useful to them as well as their family members in supporting medication adherence.

The pilot study for this dissertation started filling the gap by indicating that a TAM-based SMRA training that targets perceived ease of use with step-by-step instructions on app use is helpful in increasing the level of intention to use the app (Park et al., 2017). The dissertation research improved on the pilot study by indicating that the modified TAM-based SMRA training targets not only perceived ease of use but perceived usefulness and positive subjective norm that are also critical for promoting app use (Park et al., 2017).

**Implication for SMRA training delivery.** As reviewed previously, existing literature has suggested training principles that might help middle-aged to older adults feel comfortable engaging in SMRA training, including providing hands-on experience with app features and small peer group training (Gatti et al., 2017; Grindrod et al., 2014; Xie, 2011). Findings from this dissertation extend existing SMRA training literature by considering better ways to reach out to and deliver modified TAM-based SMRA training to middle-aged to older population. Specifically, first, for a larger efficacy study, scheduling iPhone user-only and Android phone user-only modified TAM-based SMRA training separately would be helpful to both participants and trainer. Participants could learn about SMRA without feeling confused by instructions on app use for different phone users, and the trainer could ensure that participants follow the instructions in a step-by-step manner instead of dividing attention between the needs of different phone users. Second, the results indicate that providing not only a face-to-face modified TAM-based SMRA training option but also a live online training option (e.g., Skype,

FaceTime) could be helpful in reaching out to participants without time and location constraints. Third, consistent with what previous study on Internet technology training for older adults has suggested (Chiu, Tasi, Yang, & Guo, 2019), providing small group training with peer helpers would be helpful in making sure that multiple participants with different levels of tech-savviness are on the same page in learning about an SMRA. Fourth, tailoring training length to participant preference (in relation to time-availability or tech-savviness) could help users feel more comfortable learning about the SMRA. Fifth, similar to what previous research on health-related virtual world technology training for older adults suggested (Cook & Winkler, 2016), the feedback received in the phone interviews suggests that providing training through video material and handouts, in addition to trainer-led modified TAM-based SMRA training, would be helpful to participants in learning about the app at their own pace and through repetitive practice. Sixth, working with family members and healthcare providers would be helpful in ensuring participants' medication adherence using an SMRA and reaching out to and training participants across healthcare facilities, respectively.

Inviting family members to be trained along with the participant could assist in learning features, such as Medfriend, and could be helpful in building a support network where the participants could better engage in medication adherence or communicate medication information to healthcare provider. The utility of working with family members in supporting patients in medication adherence is evidenced by existing literature. In one study on medication adherence among patients with schizophrenia (Kopelowicz et al., 2015), the intervention that engaged participants and their family members in group session (e.g., discussion and correction of inaccurate and negative

subjective norm regarding medication adherence) was found to be helpful in promoting participants' medication adherence through targeting positive subjective norm.

In addition, working with healthcare professionals (e.g., certified health managers, nurse educators, support group meeting moderators) as co-trainers could be helpful in training patient groups in healthcare facility settings. There is a precedent for involving healthcare professionals in training in some existing literature. In Dou et al.'s (2017) study, a certified health manager served as a trainer, helping patients use a smartphone hypertension management app. In addition, in Verwey et al.'s (2014) study, a nurse trained patients with type 2 diabetes or chronic obstructive pulmonary disease to use a physical activity monitoring system (an accelerometer recording patient's physical activity information sends the information to smartphone app and website) to promote physical activity. In addition, a nurse monitored and provided feedback on patient progress in physical activity recorded in the system. In the study, patients' level of physical activity significantly increased when compared to baseline. In sum, working with family members and health professionals could be helpful in delivering modified TAM-based SMRA training to participant groups and in meeting its goals.

**Practical implications.** The findings from this dissertation suggest the utility of the modified TAM-based SMRA training for SMRA developers to promote middle-aged to older adults' app use. iPhone/Android phone users visit App Store/Google Play to search for apps they are interested in and need, and app descriptions there may influence potential users' decision on downloading and utilizing the apps. Following the results of this dissertation, it is suggested that SMRA (different from Medisafe® app) developers first collect current middle-aged to older app users' opinions in relation to app features

that they find helpful for supporting medication adherence in the real-world setting (perceived usefulness and positive subjective norm) and those that they find confusing and difficult to use (perceived ease of use). SMRA developers could do so via channels including the contact or review section as part of their app description page at App Store/Google Play. Next, to target perceived usefulness and positive subjective norm, it is suggested that SMRA developers design and post app descriptions in ways that emphasize the real-world utility of the app for middle-aged to older adults as well as their family members and healthcare providers. Existing studies (Lu, 2013; Zebregs et al., 2015) and this dissertation suggest that a narrative format is particularly helpful. In addition, to target perceived ease of use, it is suggested that SMRA developers (1) design and post app training material (e.g., posting app training videos or the link to YouTube videos on app description page) with step-by-step instructions on app features found to be confusing and difficult to use by current middle-aged to older app users, and (2) make live online training opportunity available, as suggested by research participants in this dissertation.

For the Medisafe® app, Medisafe Inc. could utilize the content of the modified TAM-based SMRA training to target TAM variables and, thereby, promote app use by middle-aged to older adults. For example, to target perceived usefulness and positive subjective norm, it is suggested that Medisafe Inc. emphasizes Medisafe® app features that middle-aged older adults as well as their family members and healthcare providers could benefit from (as suggested by dissertation and pilot study participants) in narrative format as part of their app description page. To target perceived ease of use, it is suggested that Medisafe Inc. (1) posts Medisafe® app training video with step-by-step

instructions on app features—as they update the version of the app—on their current YouTube channel (<https://www.youtube.com/user/MDFSProject/videos>), (2) posts app training videos or the link to YouTube videos on app description page, (3) uses an additional heading on the app description page that clearly directs potential middle-aged to older users to the link for written app instructions, and (4) makes a live online training opportunity available, so that potential middle-aged to older adults could better benefit from app training and feel comfortable using the app.

### **Limitations**

There are limitations of this dissertation that readers should consider in interpreting the results. I will discuss limitations including ceiling effect, selection effect, potential difference in clinical importance of effect sizes for different chronic conditions, and barriers to reliable assessment of medication adherence variables.

**Ceiling effect.** As mentioned previously, one of original inclusion criteria for this dissertation study was “managing a chronic condition with at least three prescribed medications for at least three months,” in an attempt to recruit those who might feel difficulty taking multiple medications on time. However, participant recruitment was the biggest challenge for this dissertation and, to facilitate participant recruitment within the limited recruitment time period, I ended up deciding to recruit those taking a medication for chronic condition management, irrespective of medication number and type (e.g., prescribed medication, vitamin, supplement). More than half of training group participants (60%, 9/15) reported taking three or fewer medications (indicating relatively simple medication regimens), and those who reported taking one medication comprised 20% (3/15) of the training group (see Table 2).

Modified TAM-based SMRA training was not viable in increasing the level of medication adherence, but the training group participants reported moderate to high levels of medication adherence throughout the research period. These findings indicate a ceiling effect (Salkind, 2010) that makes precise assessment of the utility of modified TAM-based SMRA training difficult. In other words, the training group participants without critical difficulty remembering to take medications might report moderate to high levels of medication adherence regardless of whether or not they received modified TAM-based SMRA training.

Training group participants in this research might have reasons for medication nonadherence other than forgetting to take medications (that the modified TAM-based SMRA training helps address). For example, existing studies have indicated that patients with chronic conditions who believe medication adherence is critical to condition management are more likely to engage in medication adherence, whereas those who are concerned with medications, such as feeling uncertain and worried about medications (e.g., long-term effects of medications, becoming heavily reliant on medications; Horne, Weinman, & Hankins, 1999), are less likely to engage in medication adherence (Jessop & Rutter, 2003; Nicklas, Dunbar, & Wild, 2010; Wilhelm et al., 2018). In addition, existing literature indicated that patients might consider their condition as external or “something that attacked the individual from outside” (p. 82) that they cannot exert control over (Goering, 2015). Those who attribute their condition to external factors (e.g., pollution, other people, or chance rather than their own behaviors) are likely to report medication nonadherence (Jessop & Rutter, 2003). In addition, a report from the National Community Pharmacists Association indicates that although forgetting to take or fill

medications as prescribed is the most frequent reason for medication nonadherence among middle-aged to older adults with chronic conditions, there are other reasons such as side effects or thinking that medication adherence does not work on or is not needed for condition management (Langer Research Associates, 2013).

Considering such reports, training group participants for this dissertation might report medication nonadherence for reasons different from forgetting to take medications, such as doubts and concerns about medications and their effects. Previous research indicated a potential link between such negative perceptions of medications (e.g., addiction, impaired quality of life) and unwillingness to continue them (Matthias, Donaldson, Jensen, & Krebs, 2018). If that is the case for training group participants in the current research, interventions that educate about medications, such as correct information about side effect and its management, might be more helpful than modified TAM-based SMRA training in improving their medication adherence over time.

**Selection effect.** The research conducted for this dissertation was not a randomized controlled trial. As reported previously, the non-training group participants were significantly older than the training group participants, and existing literature indicated that older age is related to higher level of medication adherence (Kirkman et al., 2015). Although the findings did not reach significance, age differences between training and non-training groups—due to non-randomization—might result in higher level of medication adherence variables in the non-training group than in the training group. These findings indicate a selection effect (Grove et al., 2013; Wrench et al., 2013) making precise assessment of the utility of modified TAM-based SMRA training

(through comparison of outcome variables between similar age groups with and without training) difficult.

**Potential difference in clinical importance of effect sizes for different chronic conditions.** This dissertation revealed the effect sizes for the modified TAM-based SMRA training on TAM variables and intention to use the app for participants with chronic conditions, not with specific type of condition. Existing literature indicated that people differ in medication adherence depending on chronic condition type (Rolnick et al., 2013). People with different conditions might differ in the degree to which the effect sizes for the modified TAM-based SMRA training are clinically important. For example, those with asthma and diabetes report poorer level of medication adherence than those with other conditions (Rolnick et al., 2013). Thus, effect sizes for the modified TAM-based SMRA training on TAM variables and intention to use the app (as a way to support medication adherence) might be clinically more important for these individuals than for those with other conditions. In sum, the clinical importance of effect sizes for the modified TAM-based SMRA training on TAM variables and intention to use the app for this dissertation should not be generalized to middle-aged to older adults across chronic conditions.

**Barriers to reliable assessment of medication adherence variables.** There are three potential barriers to assessing medication adherence variables in this dissertation. First, all medication adherence variables for this dissertation were measured using self-report methods that are subject to recall memory bias and social desirability bias (Stirratt et al., 2015) defined as “the tendency of subjects to respond to test items in such a way as to present themselves in socially acceptable terms in order to gain the approval of others”



(King & Bruner, 2000, p. 81). In other words, participants in this research (both non-training group participants and training group participants) might inaccurately remember and overestimate their levels of medication adherence variables.

In addition, participants might report their levels of medication adherence variables as a favor to me, who introduced SMRA as a way to support their medication adherence. Similarly, participants might describe their perceptions of SMRA in relation to TAM variables (qualitative data supplements quantitative results) in a positive way if they thought I wanted a favorable evaluation of app training. This bias might include a highly positive subjective norm among those who might not have discussed or used the app with family members or healthcare providers. Martin and Upvall (2016), who introduced SMRA to those with HIV indicated such a possibility, saying:

Our study provided an understanding of the process by which the participants engaged in better HIV medication adherence with the support of a mobile phone application. [...] We believe that it may be the combination of a medication adherence tool, [...] in conjunction with the participants' perceived caring effect of the researchers over a 3-month period that contributed to increased medication adherence by the study participants. Participants may have desired to please the researchers, who had taken an interest in their medication adherence behaviors (p. 814).

A second barrier to reliable assessment of medication adherence variables is a limited research time period. Previous studies that assessed the relationship between app use and medication adherence tracked adherence for three months after the intervention (Mira et al., 2014; Morawski et al., 2018; Santo et al., 2019). One possible explanation for the lack of statistically significant differences in medication adherence in the current study might be that one month is an insufficient time period to expect significant change in the levels of medication adherence variables.

A third barrier to reliable assessment is that the medication adherence variables were collected using different survey methods. I collected baseline medication adherence data using a paper-and-pencil survey questionnaire and collected second follow-up medication adherence data using an online survey questionnaire. Existing studies have indicated that people might differ in survey responses depending on survey methods (Bates & Cox, 2008) and that the older the responders are, the more likely their survey responses are to vary depending on survey methods (Zhang, Kuchinke, Woud, Velten, & Margraf, 2017).

Considering that non-training group participants were significantly older than training group participants, the non-training group participants' self-report of their level of medication adherence might vary more depending on whether they do so on the paper-and-pencil survey questionnaire or online survey questionnaire. In conclusion, medication adherence variable data for this dissertation study should not be considered as an absolutely reliable reflection of participants' levels of medication adherence.

### **Future Directions**

There are some suggestions for future research. I will discuss future directions including theory test and extension, targeted participant recruitment, and studies regarding the reliable assessment of medication adherence.

**Theory test and extension.** The research conducted for this dissertation was not a predictive or model-testing study, and the causal relationship between modified TAM-based SMRA training and its outcomes should not be assumed. Future research with a predictive or model-testing design (using regression analysis or structural equation modeling; Grove et al., 2013) could be helpful in ascertaining the causal relationships

between modified TAM-based SMRA training and perceived usefulness, perceived ease of use, positive subjective norm, and intention to use the app. Additionally, research could investigate the causal relationship between intention to use an SMRA and active app use and between active app use and medication adherence.

For this study, I measured demographic variables and eHealth technology use variables (i.e., health-related smartphone use and Medisafe<sup>®</sup> app use self-efficacy) to assess between-group differences in these variables at baseline (for the assessment of potential selection effect), not to assess the impacts that these variables might have on the outcomes of modified TAM-based SMRA training.

As mentioned previously, higher levels of eHealth technology use variables (e.g., app use self-efficacy) have been related to greater perceived ease of use (Cho, Quinlan, et al., 2014; Dou et al., 2017). In addition, existing studies have indicated that people differ in their level of eHealth literacy depending on demographic variables (Knapp, Madden, Wang, Sloyer, & Shenkman, 2011; Xesfingi & Vozikis, 2016) and that eHealth literacy is positively related to app use self-efficacy (Cho, Park, et al., 2014). Considering these reports, training group participants might differ in terms of TAM variables, such as perceived ease of use, depending on demographic and eHealth technology use variables. Future research should extend the TAM framework used in this dissertation by assessing the roles of demographic and eHealth technology use variables as moderators between modified TAM-based SMRA training and TAM variables. Doing so could be helpful in (1) assisting target groups that are most in need of modified TAM-based SMRA training (e.g., demographic groups with the lowest levels of eHealth literacy and eHealth

technology use variables) to understand and utilize app to support medication adherence, and (2) informing the design of app training tailored to specific levels of eHealth literacy.

**Targeted participant recruitment.** Modified TAM-based SMRA training could be helpful in increasing the level of medication adherence for individuals who struggle with following and managing complex medication schedules (e.g., taking multiple medications at different times of day and keeping track of multiple medications that differ in remaining doses and time to be refilled). Future research recruiting these individuals could be helpful in assessing the utility of the modified TAM-based SMRA training without the ceiling effects of the current study.

In addition, the majority of participants in this dissertation were white with high education and income levels. Existing studies have indicated that people differ in the level of medication adherence depending on demographic variables (Kirkman et al., 2015; Marcum et al., 2013; Rolnick et al., 2013), and the findings from this study should not be generalized to individuals who are non-white and with low education and income levels without caution. Future research recruiting participants from diverse racial and ethnic groups and a wide range of education and income levels could be helpful in assessing the utility of the modified TAM-based SMRA training for participants across demographic categories.

**Suggestion for reliable assessment of medication adherence variables.** There are suggestions regarding how to assess medication adherence variables in a more reliable manner and with above limitations addressed. First, assessing participants' level of social desirability bias using the Marlowe-Crowne social desirability scale (Crowne & Marlowe, 1960) or the 13-item short-form of this scale (Reynolds, 1982) and analyzing

social desirability bias as a control variable (Carey, Lust, Reid, Kalichman, & Carey, 2016; Dunkel & van der Linden, 2014) could be helpful to reliably assess self-reported medication adherence. In addition, using more objective medication adherence measurement methods could complement findings from self-reported medication adherence data. Such methods include the medication event monitoring system (in which the lid on a pill bottle that electronically records when the bottle is opened; Garfield, Clifford, Eliasson, Barber, & Willson, 2011) and the digital medicine system (Proteus Discover developed by Proteus Digital Health Inc.). This system involves a sensor in a medication that sends information about whether and when the medication was ingested to a wearable sensor patch and to patients' and healthcare providers' mobile devices (Profit et al., 2016; Krcmarik, 2018). It is important to consider, however, the cost burden of using such methods and privacy concerns that participants might have regarding the security of their medication adherence data (Garfield et al., 2011; Vallejos & Wu, 2017).

Second, measuring and assessing the change in the levels of medication adherence variables for at least three monthly measurement points could be helpful in ascertaining potential impacts that time might have on medication adherence variables. Third, assessing medication adherence variables using the same survey method for all measurement points could be helpful in addressing the impact of different survey methods on survey responses. For example, a link to an online survey could be sent to participants via text message for all measurement points. In this way, data could be collected using the same method before, immediately after, and one month after the modified TAM-based SMRA training or self-app navigation.

## **Strengths**

Despite these limitations, this dissertation had important strengths. First, this dissertation points to the importance of health communication in promoting SMRA use by middle-aged to older adults whose self-adoption and use of app might be hindered by age-related limited eHealth literacy. Findings from this study indicate that communicating the content of modified TAM-based SMRA training, such as introducing the real-world utility of SMRA through previous app users' (pilot study participants) statements in narrative format, is helpful in leading participants to realize the value of app use in overcoming potential struggles in medication adherence. In addition, communicating instructions on SMRA use to participants in a step-by-step manner appeared to help them find the app usable. In sum, the modified TAM-based SMRA training could be deemed a health communication intervention—with messages targeting TAM variables—guiding middle-aged to older adults through the app, helping them to be app literate and, thereby, hopefully leading them to use the app to support medication adherence.

Second, among chronic conditions, heart disease is reported as the first and second leading cause of mortality in U.S. adults aged 65 years and older and those aged 45 to 64 years, respectively (Heron, 2019). The majority of participants for this research (67% of the training group and 62% of the non-training group) reported having high blood pressure that is associated with high risk of heart failure (Ettehad et al., 2016), and medication adherence is critical to preventing heart failure (Fitzgerald et al., 2011). Considering these reports, findings from this dissertation indicate the strength of modified TAM-based SMRA training—with medium to large effect size—in promoting

app use among those with high blood pressure as a way to support medication adherence and reduce the risk of heart failure.

Third, methodologically, the utility of the modified TAM-based SMRA training in targeting TAM variables was assessed in a quantifiable and reliable manner. When compared to the pilot study with posttest-only design (Park et al., 2017), this research employed a pretest-posttest design that helped assess not only whether but the degree to which the modified TAM-based SMRA training is helpful in meeting its goals. Doing so is important for attributing the improvement in the levels of TAM variables to the training. In addition, there was the short time interval between first and second TAM and intention to use an SMRA variable measurement that might be subject to recall “memory effects artificially enhancing response consistency” (Lowman, Wood, Armstrong, Harms, & Watson, 2018, p. 899). For both the first and second survey, Cronbach alpha scores indicated acceptable reliability of TAM and intention to use an SMRA variable scales: perceived usefulness (Cronbach’s  $\alpha = .95-.96$ ), perceived ease of use (Cronbach’s  $\alpha = .96$  for both first and second survey), positive subjective norm (Cronbach’s  $\alpha = .80-.82$ ), and intention to use an SMRA (Cronbach’s  $\alpha = .95-.98$ ). I measured TAM variables and intention to use an SMRA before and immediately after the modified TAM-based SMRA training (training group) and self-app navigation (non-training group). The training group completed the first and second survey on the same day, and the non-training group completed the first and second survey within a 2- to 13-day interval. Considering such a short-time interval between first and second TAM variable measurement, participants might respond to the TAM variable measurement items during the second survey in a way that is similar to the first survey because they remembered TAM and intention to use

an SMRA variable measurement items rather than because of internal consistency of measurement items. However, following previous research conducted to address such potential memory effects (Lowman et al., 2018), I measured a variety of other variables (medication adherence variables, Medisafe<sup>®</sup> app use self-efficacy, health-related smartphone use, and demographic variables) between the first and second TAM and intention to use an SMRA variable measurement. In doing so, potential participant memory effects on the second TAM and intention to use an SMRA variable measurement were mitigated. In other words, the reliabilities of TAM and intention to use an SMRA variable scales are attributable to the internal consistency of measurement items.

## **Conclusion**

The findings from this dissertation confirm that the modified TAM-based SMRA training is viable in leading middle-aged to older adults with chronic conditions to use the app through targeting perceived usefulness, perceived ease of use, and positive subjective norm. Potential impacts of modified TAM-based SMRA training on medication adherence variables might be more reliably assessed by assessing social desirability bias as a control variable, by using the same survey method to assess medication adherence variables during baseline and follow-up periods, and by assessing medication adherence variables using objective methods along with subjective methods. Estimation of the effect sizes for the modified TAM-based SMRA training on perceived usefulness, perceived ease of use, positive subjective norm, and intention to use the app indicated at least 52 participants as a sufficient sample size for a larger efficacy study.

The results of this research suggest several strategies for delivering the TAM-based training more effectively. These strategies include providing app training to same



phone users when scheduling group meetings, making both face-to-face and live online training option available, working with peer helpers in a small group training setting, providing app training materials as a post-training app practice tool, taking participants' time availability and tech-savviness into consideration to plan training length, and inviting family members (as co-trainees) and healthcare providers (as co-trainers) to app training. Using these strategies, the modified TAM-based SMRA training could better help future participants feel at ease and find value in integrating app use into addressing specific barriers to medication adherence in their lives and, thereby, to use the app to improve medication adherence and management of chronic conditions.

## APPENDICES

### APPENDIX A

#### SURVEY QUESTIONNAIRE

##### First Survey

How much do you think the Medisafe® app is helpful to your medication management? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. Using the Medisafe® app would help me quickly check what medications I should take.							
2. Using the Medisafe® app would help me to better track what medications I should refill.							
3. Using the Medisafe® app would help me to not miss taking my medications.							
4. Using the Medisafe® app would help me to remember to take my medications at the right time.							
5. Using the Medisafe® app would make it easier to track whether I have taken my medications or not.							
6. I would find the Medisafe® app to be useful in tracking that I am taking medications as prescribed.							

How much did you feel at ease using the Medisafe® app? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. Learning to use the Medisafe® app was easy for me.							
2. I found it easy to get the Medisafe® app to do what I want it to do to manage my medications.							
3. Using the Medisafe® app was clear and understandable.							
4. I found the Medisafe® app to be flexible to use.							
5. It was easy for me to become skillful at using the Medisafe® app.							
6. I found the Medisafe® app to be easy to use.							

What would your family members or healthcare providers (e.g., doctors, nurses) think about you using the Medisafe® app? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. They would think that using the Medisafe® app is important to me.							
2. It is important to them that I continuously use the Medisafe® app.							
3. It really would not matter to them if I decided to give up using the Medisafe® app.							
4. They would expect me to continuously use the Medisafe® app.							
5. None of them would really be surprised if I just stopped using the Medisafe® app.							
6. They would probably be disappointed in me if I just decided to stop using the Medisafe® app.							
7. They would probably make me feel guilty if I quit using the Medisafe® app.							

Will you use the Medisafe® app in the future? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. I intend to use the Medisafe® app in the next 3 months.							
2. I predict I would use the Medisafe® app in the next 3 months.							
3. I plan to use the Medisafe® app in the next 3 months.							

How good are you at medication taking as prescribed? Please check one of the five alternatives for each statement (from strongly disagree to strongly agree).

Over the past 7 days...	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
1. I took all doses of my prescribed medication.					
2. I missed or skipped at least one dose of my prescribed medication.					
3. I was not able to take all of my prescribed medication.					

People who take medications report trouble remembering to take their medications. How often do you have trouble remembering to take all your medications? Please check one of the five alternatives (from never/rarely to always).

Never/Rarely	Once in a While	Sometimes	Often	Always

When do you refill your prescription? Please check one of the five alternatives.

When I Run Out	A Couple Days Before I Run Out	A Couple Days After I Have Run Out	It Varies	Sometimes I Go a Few Days Without Taking My Medications

How confident are you with medication taking? Please check one of the four alternatives for each statement (from not at all sure to extremely sure).

How confident are you that you can take your prescribed medications ...	Not at All Sure	A Little Sure	Fairly Sure	Extremely Sure
1. When you are busy at home				
2. When there is no one to remind you				
3. When you worry about taking them for the rest of your life				
4. When you do not have any symptoms				
5. When you are with family members				
6. When you are in a public place				
7. When the time to take them is between your meals				
8. When you are travelling				
9. When you take them more than once a day				
10. When you have other medications to take				
11. When you feel well				
12. If they make you want to urinate while away from home				

How sure are you with that you can carry out the following task? Please check one of the four alternatives (from not at all sure to extremely sure).

	Not at All Sure	A Little Sure	Fairly Sure	Extremely Sure
Make taking your medications part of your routine				

You had 10 minutes with the Medisafe® app. How confident are you with using Medisafe® app? Please check one of the seven alternatives for each statement (from not at all confident to totally confident).

I could use the Medisafe® app ...	Not at All Confident 1	2	3	Moderately Confident 4	5	6	Totally Confident 7
1. ... if there was no one around to tell me what to do as I go.							
2. ... if I had never used a package like it before.							
3. ... if I had only the software manuals for reference.							
4. ... if I had seen someone else using it before trying it myself.							
5. ... if I could call someone for help if I got stuck.							
6. ... if someone else had helped me get started.							
7. ... if I had a lot of time to complete the job for which the software was provided.							
8. ... if I had just the built-in help facility for assistance.							
9. ... if someone showed me how to do it first.							
10. ... if I had used similar packages before this one to do the same job.							

Have you ever used your smartphone for following reasons? Please check one of the two alternatives for each statement (yes or no).

Think about the last 12 months. Did you use smartphone apps ...	YES	NO
1. to quit smoking		
2. to be regularly physically active		
3. to maintain a healthy diet		
4. to reduce weight		
5. to take medications regularly		
6. to improve blood pressure control		
7. to improve blood sugar control		
8. to look for information about a “specific disease or medical problem,” “certain medical treatments or procedures,” “how to lose weight or how to control your weight,” “health insurance, including private insurance, Medicare or Medicaid,” “food safety or recalls,” “drug safety or recalls,” “a drug you saw advertised,” “medical test results,” “caring for an aging relative or friend,” “pregnancy and childbirth,” “how to reduce your health care costs,” etc.		
9. I use smartphone apps to improve health behaviors or look for health information		

### Demographic Questions

What is your gender?

- (1) Female  
 (2) Male  
 (3) Other (Please write in here: )

How old are you? ( ) years old

What is your ethnicity? (Please check one)

- (1) Hispanic or Latino
- (2) Not Hispanic or Latino
- (3) Unknown or do not want to report

What is your race? (Please check one)

- (1) American Indian or Alaska Native
- (2) Asian
- (3) Black or African-American
- (4) Native Hawaiian or Other Pacific Islander
- (5) White
- (6) Unknown or do not want to report

What is your education level? (Please check the highest level attained)

- (1) Less than high school
- (2) High school diploma or GED
- (3) Some college
- (4) Associate's (2-year) degree
- (5) Bachelor's (4-year) degree
- (6) Post-bachelor's degree (e.g., graduate degree, professional degree)

Does your income leave you ... (Please check one you agree with)

- (1) Comfortable
- (2) Having just enough to make ends meet
- (3) Having not enough to make ends meet

Do you have any of the following medical problems? (Please check all that apply)

- (1) Anemia or other blood disease    (2) Arthritis (osteoarthritis, degenerative arthritis, rheumatoid arthritis)
- (3) Asthma    (4) Back pain    (5) Cancer    (6) Chronic obstructive pulmonary disease (COPD)
- (7) Emphysema    (8) Heart disease    (9) High blood pressure    (10) Kidney disease
- (11) Liver disease    (12) Ulcer or stomach disease
- (13) Other problems? (Please write in here: \_\_\_\_\_ )

How many different medications are you currently prescribed to take? ( \_\_\_\_\_ )

Are any of them anti-psychotic medications?

- (1) Yes    (2) No

How many other medications (e.g., vitamins, supplements, etc.) are you currently taking to help manage your conditions? ( \_\_\_\_\_ )

Do you have a caregiver?

- (1) Yes    (2) No

Does your caregiver manage your medications?

- (1) Yes    (2) No, I manage my own medications

Who is your primary caregiver? (Skip question if not applicable)

(1) Spouse (2) Child (3) Other relative (4) Friend or neighbor  
(5) Other (Please specify: )

Do you live with your caregiver? (Skip question if not applicable)

(1) Yes (2) No

Have you ever used a smartphone app as a reminder to take your medications?

(1) Yes (2) No

## Second Survey

How much do you think the Medisafe® app is helpful to your medication management? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. Using the Medisafe® app would help me quickly check what medications I should take.							
2. Using the Medisafe® app would help me to better track what medications I should refill.							
3. Using the Medisafe® app would help me to not miss taking my medications.							
4. Using the Medisafe® app would help me to remember to take my medications at the right time.							
5. Using the Medisafe® app would make it easier to track whether I have taken my medications or not.							
6. I would find the Medisafe® app to be useful in tracking that I am taking medications as prescribed.							

How much did you feel at ease using the Medisafe® app? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. Learning to use the Medisafe® app was easy for me.							
2. I found it easy to get the Medisafe® app to do what I want it to do to manage my medications.							
3. Using the Medisafe® app was clear and understandable.							
4. I found the Medisafe® app to be flexible to use.							
5. It was easy for me to become skillful at using the Medisafe® app.							
6. I found the Medisafe® app to be easy to use.							

What would your family members or healthcare providers (e.g., doctors, nurses) think about you using the Medisafe® app? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. They would think that using the Medisafe® app is important to me.							
2. It is important to them that I continuously use the Medisafe® app.							
3. It really would not matter to them if I decided to give up using the Medisafe® app.							
4. They would expect me to continuously use the Medisafe® app.							
5. None of them would really be surprised if I just stopped using the Medisafe® app.							
6. They would probably be disappointed in me if I just decided to stop using the Medisafe® app.							
7. They would probably make me feel guilty if I quit using the Medisafe® app.							

Will you use the Medisafe® app in the future? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. I intend to use the Medisafe® app in the next 3 months.							
2. I predict I would use the Medisafe® app in the next 3 months.							
3. I plan to use the Medisafe® app in the next 3 months.							

(Non-training group only) Open-ended questions

1. Overall, how do you like the Medisafe® app?
2. Will you use this app to support you taking your medications in future? Why?
3. Do you think the Medisafe® app is easy to use? Why?
4. Do you think the Medisafe® app will be helpful to medication taking? Why?
5. What do you think your family members or healthcare providers would say about you using the Medisafe® app?
6. During the group session today, how did you go about figuring out how to use Medisafe® app features (e.g., use of online app training video, discussion with other participants, self-navigation of app features)? Please be specific.
7. Do you think it would have been easier to use Medisafe® app features if you had received app training?
8. Could you provide suggestions for the format of Medisafe® app training you would like to receive (e.g., face-to-face vs. online training, group vs. individual training)?
9. Could you provide suggestions for the content of Medisafe® app training you would like to receive (e.g., instructions on specific app features)?
10. Any other suggestions for delivering Medisafe® app training to people like you?

Please leave your email address below so that you can receive a link to a third and online survey one month after today Email address:\_\_\_\_\_



### Third Survey

How good are you at medication taking as prescribed? Please check one of the five alternatives for each statement (from strongly disagree to strongly agree).

Over the past 7 days...	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
1. I took all doses of my prescribed medication.					
2. I missed or skipped at least one dose of my prescribed medication.					
3. I was not able to take all of my blood pressure medication.					

People who take medications report trouble remembering to take their medications. How often do you have trouble remembering to take all your medications? Please check one of the five alternatives (from never/rarely to always).

Never/Rarely	Once in a While	Sometimes	Often	Always

When do you refill your prescription? Please check one of the five alternatives.

When I Run Out	A Couple Days Before I Run Out	A Couple Days After I Have Run Out	It Varies	Sometimes I Go a Few Days Without Taking My Medications

How confident are you with medication taking? Please check one of the four alternatives for each statement (from not at all sure to extremely sure).

How confident are you that you can take your prescribed medications ...	Not at All Sure	A Little Sure	Fairly Sure	Extremely Sure
1. When you are busy at home				
2. When there is no one to remind you				
3. When you worry about taking them for the rest of your life				
4. When you do not have any symptoms				
5. When you are with family members				
6. When you are in a public place				
7. When the time to take them is between your meals				
8. When you are travelling				
9. When you take them more than once a day				
10. When you have other medications to take				
11. When you feel well				
12. If they make you want to urinate while away from home				

How sure are you with that you can carry out the following task? Please check one of the four alternatives (from not at all sure to extremely sure).

	Not at All Sure	A Little Sure	Fairly Sure	Extremely Sure
Make taking your medications part of your routine				

(Training group only) What do you think Medisafe® app training session as an introductory course in app use? Please check one of the seven alternatives for each statement (from strongly disagree to strongly agree).

Please indicate the degree of your agreement with each statement	Strongly Disagree	Moderately Disagree	Somewhat Disagree	Neither Disagree nor Agree	Somewhat Agree	Moderately Agree	Strongly Agree
1. Medisafe® app training I had received made me think more about using the app.							
2. I started using the Medisafe® app because of the app training I had received.							

How often do you use Medisafe® app to take your prescribed medications?

Don't use at all	Use about once each week	Use several times a week	Use about once each day	Use several times each day	Always use to take prescribed medications

Which phone do you use?

(1) iPhone      (2) Android phone

What is your email address (that you received this survey link)?

Email address: \_\_\_\_\_

## APPENDIX B

### TELEPHONE INTERVIEW GUIDE

Thank you very much for sparing your time for the telephone interview that will help me gain insight into a smartphone medication reminder app (as a way to support medication taking) and app introduction session (as a way to support app use).

As a kind reminder, may I ask if I could audio-record this interview for the purpose of transcription and data analysis? I will remove any identifying information mentioned during the interview from the final transcript.

Thank you very much. I have a series of questions I would like to ask you now as you have had a month to use the Medisafe® app.

Overall, how do you like the Medisafe® app?

Are you using this app to support you taking your medications? (*Actual app use*)

- Could you tell me more about why you keep using the app?
  - Is the app helpful? When and how is the app helpful? (*Perceived usefulness*)
  - Is the app easy to use? (*Perceived ease of use*)
  - Would your family members or healthcare providers think positively of you using the app? (*Subjective norm*)
- Will you continue using the app? (*Intention to use the app*)

OR

- What has prevented you from using it?
  - Is the app unhelpful? Why? (*Perceived usefulness*)
  - Is the app too difficult to use? Time consuming? (*Perceived ease of use*)
  - Would your family members or healthcare providers be concerned about you using the app? (*Subjective norm*)

Thank you very much for sharing your thoughts about the Medisafe® app. Now I would like to ask your thoughts about Medisafe® app introduction session you received a month ago.

During the Medisafe® app introduction session, you were introduced to (1) what the app is and how it works, (2) how app features could help address the real-world struggles in medication adherence and what situations your family members or healthcare providers would think positively of you using the app, and (3) how to use virtual pillbox and reminder features for approximately 2 hours.

What do you think about Medisafe® app session as an introductory course in app use?

- How useful did you perceive the app to be after the app training? (*Perceived usefulness*)
- How comfortable did you feel about using the app after the app training? (*Perceived ease of use*)
- After the app training, how positive did you think your family members or healthcare providers would think of you using the app? (*Subjective norm*)

What feedback would you give me in making Medisafe® app introduction session to be more helpful to people like you in the future?

- Is there an additional app training content or material that you think I need to provide to participants in the future?
- Is there a specific app training content that you think is not helpful and thus needs to be excluded from the app training in the future?
- What do you think about the format of app training?
  - What do you think about face-to-face format as you received versus online app training format?
  - What do you think about training format as a small group meeting versus individual meeting?
- What do you think about the length of the app training session?
- Any other suggestions for delivering app training to people like you?

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- Zhang, X., Kuchinke, L., Woud, M. L., Velten, J., & Margraf, J. (2017). Survey method matters: Online/offline questionnaires and face-to-face or telephone interviews differ. *Computers in Human Behavior, 71*, 172-180.

## CURRICULUM VITAE

### Daniel Youngjoon Park

#### Education

- Indiana University, Indianapolis, Indiana, 2015-2019
  - Ph.D. in Health Communication
  - Dissertation: A theory-based mHealth intervention to improve medication adherence by adults with chronic conditions: Technology acceptance model-based smartphone medication reminder app training session
  - Advisor: Dr. Elizabeth Goering
- Indiana University, Indianapolis, Indiana, 2013-2015
  - M.A. in Applied Communication
  - Thesis: The health-related uses and gratifications of YouTube: Motive, cognitive involvement, online activity, and sense of empowerment
  - Advisor: Dr. Elizabeth Goering
- Hanyang University, Seoul, South Korea, 2010-2012
  - M.A. in Communication and Journalism
  - Thesis: A study on the agenda-setting effects of Twitter: Focus on the issues of the 19th general election
  - Advisor: Dr. Jung Kee Kim
- Hanyang University, Ansan, South Korea, 2003-2007
  - B.A. in Journalism and Mass Communication
  - Final Project: Critical semiotic analysis: Korean movie “The Host”

#### Awards and Award Nominations

- Nominated for **Sherry Queener Graduate Student Excellence Award** by the Department of Communication Studies at Indiana University-Purdue University Indianapolis, February 2017 and December 2017
- **Petronio-Bantz Graduate Student Travel Award** by the Department of Communication Studies and the School of Liberal Arts at Indiana University-Purdue University Indianapolis, September 2016
- Nominated for **University Graduate School Distinguished Master’s Thesis Award** by the Department of Communication Studies at Indiana University-Purdue University Indianapolis, September 2016
- **Communication Studies Graduate Academic Achievement Award** by the Department of Communication Studies and the School of Liberal Arts at Indiana University-Purdue University Indianapolis, April 2016
- **Outstanding Graduate Paper Award** by the Department of Communication Studies at Indiana University-Purdue University Indianapolis for *Antecedents of job satisfaction among intimate partner violence shelter staff: Coworker relational maintenance strategies, communication satisfaction, burnout and organizational commitment*, April 2015

## **Publications**

- Park, D. Y., Goering, E. M., Head, K. J., & Bartlett Ellis, R. J. (2017). Implications for training on smartphone medication reminder app use by adults with chronic conditions: Pilot study applying the technology acceptance model. *JMIR Formative Research*, 1(1), e5. doi:10.2196/formative.8027
- Park, D. Y., & Goering, E. M. (2016). The health-related uses and gratifications of YouTube: Motive, cognitive involvement, online activity, and sense of empowerment. *Journal of Consumer Health on the Internet*, 20, 52-70. doi:10.1080/15398285.2016.1167580

## **Presentations**

- Deason, A., & Park, D. Y. (2017, June). *Metaphors for depression among paramedics in the Code Green Campaign: An application of the job demands-resources model*. Paper presented at 15th Communication, Medicine & Ethics (COMET) Conference at Indiana University-Purdue University Indianapolis, Indianapolis, IN.
- Park, D. Y., & Bute, J. J. (2016, October). *Burnout and health problems among domestic violence service workers: Communicating social support with coworkers as a coping practice*. Paper presented at APHA 2016 Annual Meeting & Expo of the American Public Health Association, Denver, CO.
- Park, D. Y., & Goering, E. M. (2016, February). *The health-related uses and gratifications of YouTube: Motive, cognitive involvement, online activity, and sense of empowerment*. Paper presented at Media + Health Symposium 2016 of the Virginia Commonwealth University, Richmond, VA.
- Maniloff, J., Park, D. Y., Laorujiralai, K., Paholski, L., Sugumar, V., & Yates, R. (2015, April). *Antecedents of job satisfaction among intimate partner violence shelter staff: Coworker relational maintenance strategies, communication satisfaction, burnout and organizational commitment*. Poster presented at IUPUI Research Day 2015 of the Indiana University-Purdue University Indianapolis, Indianapolis, IN.

## **Leadership, Assistantships and Internship Experience**

- **Research Assistant**, Department of Communication Studies at Indiana University-Purdue University Indianapolis, Indianapolis, IN, August 2015-May 2019
  - Research assistant for Dr. Elizabeth Goering, January 2019-May 2019
    - Project topic: A communication analysis of naturally occurring intercultural interaction
      - Assistance with literature review and data analysis
  - Research assistant for Dr. Maria Brann, August-December 2018
    - Project topic: Development of communication studies graduate course
      - Assistance with participant recruitment and survey

- Research assistant for Dr. Jennifer Bute, January-May 2018
  - Project topic: Precautionary allergen labeling knowledge, perception, and practice among healthcare providers in the United States and Canada
    - Assistance with literature review and survey questionnaire design
- Research assistant for Dr. Kim White-Mills, August-December 2017
  - Project topic: Prevalence of and factors influencing incivility in healthcare organizations
    - Assistance with participant recruitment
- Research assistant for Dr. Katharine Head, January-May 2017
  - Project topic: Illness perception among patients with autosomal dominant polycystic kidney disease and its relationship with illness-related communication with family members and healthcare providers
    - Assistance with literature review and data analysis (e.g., moderation analysis)
- Research assistant for Dr. Jennifer Bute, August-December 2016
  - Project topic: Uncertainty management and quality of life in caregivers of food allergic children
    - Assistance with literature review
- Research assistant for Dr. Maria Brann, January-May 2016
  - Project topic: Working with standardized patients for improving healthcare providers' shared decision-making skills in the miscarriage context
    - Assistance with literature review
- Research assistant for Dr. Kim White-Mills, August-December 2015
  - Project topic: Parents' perceptions of parenting sources, including motive for and satisfaction with specific source use
    - Assistance with literature review and survey questionnaire design
- **Leadership Team Member**, Speaker's Lab at Indiana University-Purdue University Indianapolis, Indianapolis, IN, August 2013-May 2015
  - Mentor for undergraduate students enrolled in "Fundamentals of Speech Communication" class
    - Assistance with preparation for assignments, including brainstorming speech topics, improving speech outline, and overcoming speech anxiety
- **Intern**, Research & Research, Inc., Seoul, South Korea, July-August 2010
  - Internship at "Fieldwork" team and "Marketing & Research" team
    - Assistance with consumer perception research, including data collection (survey and focus groups) and coding
- **Intern**, Educational Broadcasting System (EBS), Seoul, South Korea, June-August 2006
  - Internship at "Early Childhood Education Program" team
    - Assistance with program filming and stage setting

**Professional Service**

- **Abstract Reviewer**, APHA 2019 Annual Meeting & Expo of the American Public Health Association, Philadelphia, PA, March 2019
- **Abstract Reviewer**, APHA 2018 Annual Meeting & Expo of the American Public Health Association, San Diego, CA, March 2018
- **Abstract Reviewer**, APHA 2017 Annual Meeting & Expo of the American Public Health Association, Atlanta, GA, March 2017